IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

Grinding the Flutes in a Marble Column

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

July 1929

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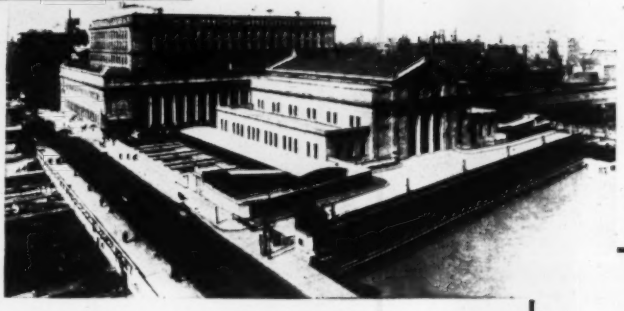

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* * *

This Month's Cover is used in connection with Mr. McCluskey's paper on "Modern Practice in the Quarrying and Milling of Marble," and shows a column drum of marble being fluted. Various types of carborundum machines are used for this type of work, replacing the old-style machines employing steel cutting tools.

MECHANICAL ENGINEERING

Volume 51 July, 1929 No. 7

Wage Incentives for Direct Labor

Ideals for Extra Financial Incentives—The Ten Plans Found by Analysis to Meet All the Requirements for Direct-Production Work—Example Illustrating the Analytical Method Employed

By CHARLES W. LYTLE,[1] NEW YORK, N. Y.

THE preparation of a book on the subject of wages, salaries, and incentives has afforded the author an opportunity for careful study and comparison of all the various schemes in common use. A method of statistical and graphical analysis applied to twenty-five plans reveals the fundamental principles more completely, it is believed, than heretofore. The present article outlines briefly the ideals for extra financial incentives, the ten plans necessary to meet all ordinary needs for the direct-production type of work, an example of the analytical method used, and throughout, the definitions and principles as they arise.

The Economic Setting

In prewar times little attempt was made to level the peaks and valleys of the primary or business cycle. Employers counted on making enough profit during a boom period to carry them through the inevitable depression period. During the depression period it was thought necessary to cut wages and to lay off large numbers of employees, even to the extent of shutting down plants. The loss of purchasing power sustained by employees, middlemen, and others did not seem as consequential to employers as at present. The declines were therefore accelerated, intensified, and prolonged. During the last decade we have succeeded in flattening the modulations of the underlying primary cycle and have superimposed a constructive secondary cycle of more productivity, cheaper manufacturing cost, higher wages, greater purchasing power, bigger markets, lower prices, and greater volume of sold production. That this has been achieved simultaneously with a reduction of working hours and a restriction of immigration, has been most encouraging. The result is that the employee now has a real task per hour and the employer a narrow margin of profit per unit, but the practice promises to give us a better guarantee of general prosperity. Also the question of wages has emerged with greater importance than ever before.

[1] Director of Industrial Cooperation, New York University. Mem. A.S.M.E.

Digested from a forthcoming book by the author, to be published by the Ronald Press, covering the whole remuneration field.

Essential Characteristics of Any Extra Financial Incentive Plan

(1) *It should be just to both employer and employee*
(2) *It should have a standardized high task and a generous reward*
(3) *It should be unrestricted as to amount of earning*
(4) *It should be reasonably simple for an employee to figure*
(5) *It should be flexible*
(6) *It should be an aid to team work*
(7) *It should have employee support*
(8) *It should have full managerial support*
(9) *It should not be used temporarily.*

Wages and Extra Financial Incentives Defined

Wages are "the reward of those who are employed in production with a view to the profit of their employers and are paid at stipulated rates."[2] Three fundamentals are evident: (*a*) the need and hope of material possession, (*b*) the expenditure of human effort to that end, and (*c*) the reward roughly in proportion to the efficiency of the effort. If we now separate (*a*) and (*c*) from (*b*) we shall have on one side the urge for and the assurance of reward, and on the other side the work necessary to bring about fulfilment. Service and reward under free institutions are equivalent and inseparable, so that any form of remuneration or profits constitutes some incentive to work. The relation between service and reward has, however, become less direct and less immediate. It has therefore become desirable to arrange plans by which a more definite and efficient work-wage contract may be secured. "Extra financial incentive plans," as they have come to be called, include all remuneration plans which provide money inducements above base-time wages for the accomplishment of definite quantity-quality-economy standards. The latter standards or tasks are variously treated, but in some form they are always prerequisite to the extra remuneration. Other incentives termed "non-financial" are also important, but they are treated here only as supporting measures. In some cases it is proper to spend more money on and to give more emphasis to these measures than to the financial incentives, but the former are never adequate as complete substitutes for the latter.

Ideals for Extra Financial Incentives

The problem is to determine the interests of management, specify them definitely, provide tests and checks, and then arrange incentives so that the interests of the employees will coincide with those of management. Broadly speaking, good management is in itself an incentive, and without it no special in-

[2] F. A. Walker, "The Wages Question."

centive can be made worth while. A unified management in which the extra financial incentive is an inseparable part is therefore the all-inclusive ideal.

It is difficult to set up a single set of detailed ideals for all plans. Special conditions have special requirements, and no one plan should be expected to meet opposing conditions. It is possible, however, to outline the essential characteristics any plan should possess for the ordinary manufacturing department. Briefly, these are:

1 It should be just to both employer and employee, increasing the mutuality of their desires. It should be positive, not unnecessarily punitive, and operated in such a way as to promote confidence.

2 It should be strong both ways, that is, it should have a standardized high task and a generous reward; the latter should usually be in direct proportion to employee effort, and preferably more than this for the highest productions. One writer puts this aptly, "It should reflect an employee's contribution to his company's success."[3]

3 It should be unrestricted as to amount of earning, that is, the rate should be guaranteed against change until the job is changed.

4 It should be reasonably simple for an employee to figure, prompt and clear in its relation to performance—preferably individual performance—as well as practical for shop procedure. The time period over which efficiency is averaged should be short, usually a day.

5 It should be flexible and intimately related to other management controls.

6 It should be an aid to team work and automatically assist supervision. The degree of this importance is one of the factors determining whether the application should be by groups or not.

7 It should have employee support and in no respect be paternalistic.

8 It should have full managerial support in the matters of production, material and quality control, maintenance, and nonfinancial incentives.

9 It should not be used temporarily in busy seasons and dropped in dull times as a means of wage reduction.

Mode of Comparing Plans With Ideals

That we may apply these ideals fairly to the various plans we must set up a basis of treatment which will reduce them to as nearly similar conditions as possible. We cannot explain the whole method here, but we can present enough of the essentials so that the interested reader may follow the conclusions with understanding. Most elemental of all is the establishment of terms and measurements which will permit exact expression. For this we resort to graphics and provide a chart which will indicate the two variables between which all earning arrangements are fixed, that is, the amount of production and the amount of earning. The former is taken as the horizontal axis and the latter as the vertical axis (see Fig. 1). These two variables may be scaled in percentages in order to allow easy application to any specific case. From these scales the point (100, 100) becomes the most important point for the comparison of all earning curves and may be referred to as the "high-task, base-wage" point. By 100 per cent base wage we mean the competitive time rate for a given job or class of work in the locality for skilled jobs—higher than the rate for common labor.

While the task standard varies among different companies, from perfection on down, it is permissible to use only two task standards, one called high and one called low, because all plans were devised for either a standardized plant or an unstandardized plant. Tasks for the former are called high and are assigned the 100 per cent location on the production scale. Tasks for unstandardized plants are called low, and as they are commonly from 60 to 65 per cent of the high task, they are assigned the $62\frac{1}{2}$ location on the production scale. The point ($62\frac{1}{2}$, 100) may be called the "low-task, base-wage" point. What the employer needs to know is how the various plans differ relatively to each other for a single task, either high or low.

Gage Points and Slopes on the Chart

High task does not mean maximum capacity or perfection. Actually it varies with the pains taken in determining it. It should be set so that most competent employees can make it day in and day out without extreme effort. Some of the more energetic employees will range around 125 per cent of it frequently, and the rare but well-known "superworker" will be able to make up to 145 per cent of it. About 150 per cent production would therefore be the perfection location, and earnings beyond this are merely theoretical.

The two most definite limits for all wage charts are "perfection" (150, 200) and "near discharge" (60, 100). The "superworker" is also fairly definite (Fig. 2). The other point locations are a matter of experience and would vary a little under different circumstances. The "low task" point is located by the record of many day workers.

Of course plans designed for one or the other of these two tasks may be grotesque if applied to the other. The least affected by task change would be the earning curve having the least slope through high production points where the greatest divergence must occur. A steep-slope plan on the other hand can give an impossibly high wage when misapplied through a low task. This is what happened so often with pre-time-study piece rates. A steep-slope earning curve must have a high task, and the steeper this slope the greater is the need for accuracy in task setting.

Fig. 3 shows three (50–50) constant-sharing earning curves, and the effect on their slopes by varying tasks. Fig. 4 shows three piece-rate earning curves, and the effect on their slopes by varying tasks.

The older emphasis on labor cost rather than the new emphasis on total cost led to the popular conception that an incentive should increase less rapidly than production. The correct postulate is that an incentive should increase as rapidly as, and, when possible, more rapidly than, production. This does not mean higher total unit cost.

Base-Rate Level May Also Vary

A lower time rate removes the main objection to day-wage guarantees in connection with extra financial incentives, but such a rate must be handled cautiously where the hiring rate is the full competitive day earning, that is, 100 per cent base wages. (See Fig. 5.)

Preliminaries to Plotting

Before a specific curve can be plotted there must be statistics covering chosen points, and before these statistics can be obtained there must be a formula for the earning under the plan in question. Such formulas are easily written from plan descriptions provided a workable set of symbols is established. The symbols given at the head of the first column of page 496 are mnemonic and have come into general use since their publication in magazine form.[4]

[3] Taylor insisted that a successful plan should offer: (*a*) laborers 30 to 60 per cent more than class, (*b*) ordinary mechanics 70 to 80 per cent more than class, (*c*) skill, brains, close application, and bodily exertion as high as 100 per cent or more than class.

[4] *Management Engineering*, May, 1922, pp. 321–324.

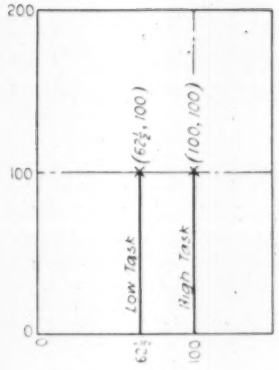


FIG. 1

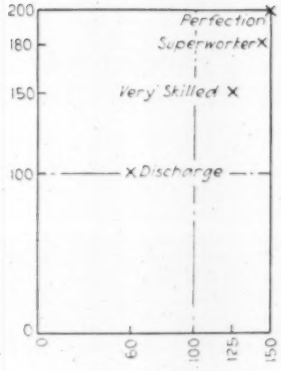


FIG. 2

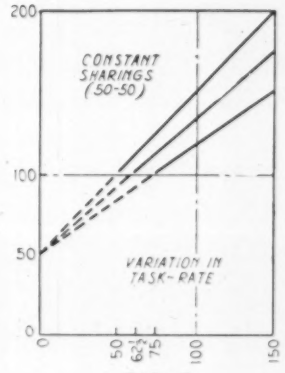


FIG. 3

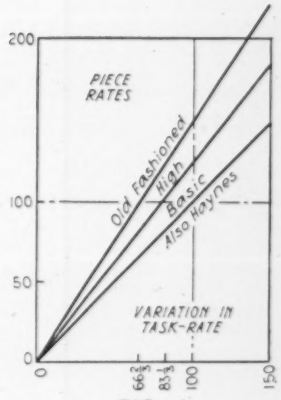


FIG. 4

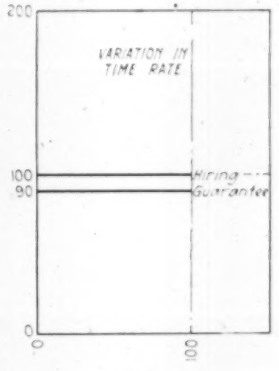
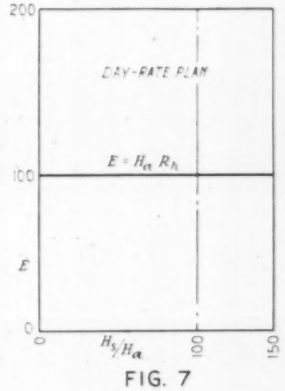


FIG. 5

FIG. 6



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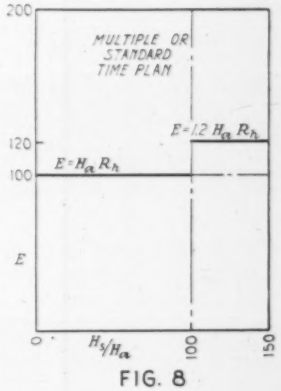

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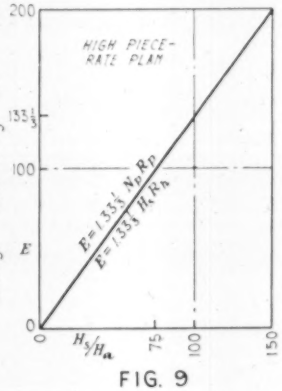


FIG. 9

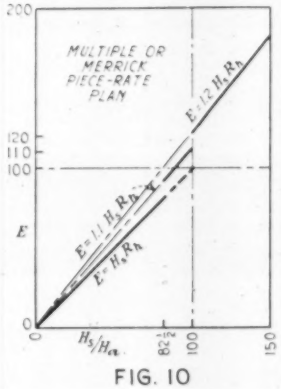
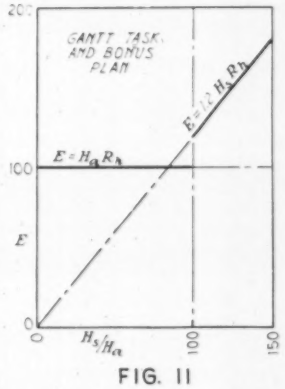


FIG. 10



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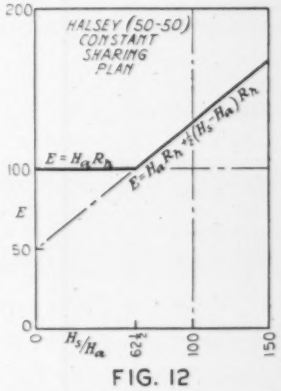

FIG. 12

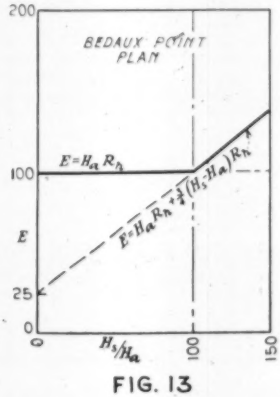

FIG. 13

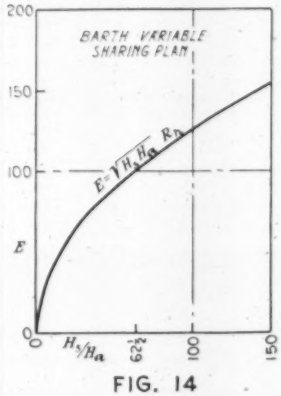

FIG. 14

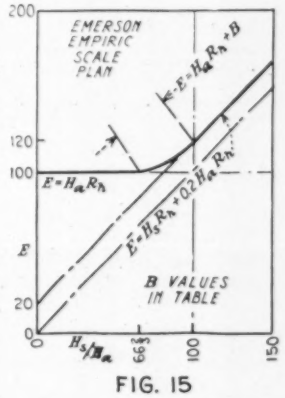

FIG. 15

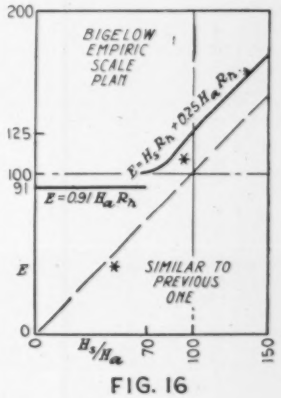

FIG. 16

FIGS. 1–16 CHARTS SHOWING EARNING CURVES AND THEIR FORMULAS

Key to symbols		Values used in specific cases
E	= earning in dollars	
N_p	= number of pieces produced	
R_p	= rate per piece in dollars	$0.16
R_h	= rate per hour in dollars	0.48
R_m	= rate for machine in dollars	0.20
H_d	= hours per full day	8 hours
R_t	= rate per time unit such as week, month, or year, in dollars	
H_a	= hours actual	
H_s	= hours standard for any given N_p	
B	= bonus in per cent of base-time wages	

Illustration of Symbols

Only a few of these symbols are necessary for most of the formulas and they can be learned by use in a few seconds. For instance, by definition:

(1) Piece-Work Earning = No. of Pieces × Rate per Piece
$E = N_p \times R_p$

(2) Time Earning = Hours Actual × Rate per Hour
$E = H_a \times R_h$

(3) Time Saved = Hours Standard — Hours Actual
(no symbol) $= H_s - H_a$

(4) Wages Saved = Times Saved × Rate per Hour
(no symbol) $= (H_s - H_a) \times R_h$

As all the twenty-five plans examined by the author, excepting those of Barth and Ficker, are made up entirely of quantities (2) and (4) or some combination of them, it is not hard to derive any earning formula. This was done and the specific points inserted so that nine examples were worked out for each plan and the earnings, costs, etc. put into tabular form. Where the wage is other than straight time, the amount figured by formula for any efficiency must be prorated through the whole eight-hour day because the data are figured for an eight-hour task rather than for eight hours of actual work. H_s/H_a becomes the variable corresponding to the production efficiency, and E becomes the variable corresponding to the earning in terms of base wages (Fig. 6).

Classification of Incentives According to Earning Formulas[5]

When we realize through analysis that time wages are independent of production and that piece wages are independent of time, it will readily be seen that there are two radically different types of financial incentives at the outset. The first time plans we shall call Class I, in which the employer takes all gain or loss related to task cost. The second piece-rate plans we shall call Class II, in which the employee takes all the gain or loss. As the sharing or premium plans fall between these two, it is necessary to establish Class III, for gain shared between employer and employees. If we now establish a fourth class on the plans eliminated by the three foregoing, Class IV includes those in which there is an empiric location of points between two variables. While this describes exactly what is done in the plans so classified, it needs to be noted that the empiric points usually lie within a certain production zone and are not scattered from low to high production. This classification should be applied to any plan as soon as the formula is determined, because class comparison must precede individual comparison.

Ten Plans Surviving Analysis

In his book the author gives full analysis for each of twenty-five plans. In this article he merely identifies and touches upon the ten plans which, as a result of analysis, provide all the important arrangements for direct-production work. As a sample of the analysis an almost complete treatment of one plan, the Gantt Task and Bonus Plan, is given later. These ten plans follow with their earning curves and outstanding advantages. In some cases only portions of the plans are recommended.

1 Day-Rate Plan with production records and promotion (Fig. 7). For unstandardized work, permanent or temporary. It is simple and about all that can be used. Management should eliminate it wherever and whenever possible.

2 Multiple Time Plan with high bonus steps (Fig. 8). For upgrading employees formerly on day rates. It is one of the strongest as well as simplest of plans. It must be more carefully managed than more elaborate plans.

3 High-Piece-Rate Plan, with or without a minimum guarantee and with the time basis of computation (Fig. 9). For repetition work, not involving expensive machine rates. It is the simplest and the most sound of all the plans. Equalization of rates requires care inasmuch as the task per unit of time may not be evident.

4 Merrick Multiple Piece-Rate Plan (Fig. 10). For upgrading inefficient employees formerly on a low-piece-rate plan. It is flexible, strong, and relatively simple for what it can do. Tables must be used for explanation and computation.

5 Gantt Task and Bonus Plan (Fig. 11—a combination of plans Nos. 1 and 3). For machine jobs liable to delay and where machine rates are high. It provides security with strength.

6 Halsey (50–50) Constant Sharing Plan (Fig. 12). For guessed-at standards, no big machine rates. It gives a high wage through intermediate production efficiencies. Task or rate inaccuracy is less momentous.

7 Bedaux Point Plan (Fig. 13). For strongly centralized management and for widely diversified operations. It gets results through its production control rather than through high rates. It involves a lot of figuring.

8 Barth Variable-Sharing Plan—up to day wages only (Fig. 14). For beginners. It gives a high wage for low production efficiencies without any guarantee. Tables must be used, for the new employee may not have a slide rule.

9 Emerson Empiric Scale Plan—between 70 per cent and 100 per cent task only (Fig. 15). For gradual transition from day-work plan to high-piece-rate plan. It avoids the abrupt step and may be justified in some cases. The empiric principle is only used within the above limits, and outside of these, other plans are preferable.

10 Bigelow-Knoeppel Constant-Sharing Plan—up to 70 per cent high task (Fig. 16). For beginners. It makes a simple and just plan for these limits, with less earning than day wage and more than piece rate. It is probably easier to understand than the Barth plan for the same purpose. It is not recommended beyond 70 per cent task.

As to the other fifteen plans discussed in the book, none has any inherent merit not to be found in the ten just enumerated, except perhaps the 15-class gradation of Parkhurst. [If the scale of Efficiency-Bonus seems important, that can be made up for any of the above plans.]

Job standardization, production control, inspection, and non-financial incentives must precede and accompany any plan to get anything worth while out of it. Similarly, any one plan may be used on a minute basis or on a group application. The author believes that these ten plans provide every kind of incentive needed today and likely to be needed for a long time to come. Various combinations of these plans are desirable, but they should not be given new names other than perhaps plant names indicating where used.

[5] First presented by author on May 18, 1927, in A. M. A. Marketing Executives Series No. 51.

PIECE-RATE PLANS

In preparation for the analysis of the Gantt plan it is necessary to develop the formulas for piece work. For the same reason it may be well to comment on them also. The term "straight piece work" means a constant rate of pay per unit of work properly produced and for all units from zero up. Any such arrangement is piece work whether the rate is little or much. The straight-line slope from the origin is its essential characteristic. Conversely, any straight-line earning curve which does not go to the origin of the chart does not represent straight piece work, and any one that cannot be extended to the origin is no variety of piece work. The piece worker no longer owns all his own tools, and rarely works under his home roof, but he may still do much as he sees fit because the amount of work per unit of time is usually not specified. Occasionally, however, a low-grade employee does so little on piece work that he is discharged, not because of the labor cost per piece, but because of the overhead, machine rate, floor space, etc. which goes into total cost. Weeding out is therefore always necessary under piece work. On the other hand, many piece workers do more than is good for their health.

FORMULA FOR EARNING—BASIC PIECE RATE

$$\begin{aligned} \text{Earning} &= \text{Number of Pieces} \times \text{Rate per Piece} \\ E &= N_p \times R_p \end{aligned}$$

$$\text{Since hours allowed per piece} = \frac{R_p}{R_h} .$$

$$N_p \frac{R_p}{R_h} = H_s$$

and

$$N_p \frac{R_p}{R_h} R_h = H_s R_h$$

$$\begin{aligned} \therefore \text{Earning} &= \text{Hours Standard} \times \text{Rate per Hour} \\ N_p R_p &= H_s \times R_h \end{aligned}$$

The latter expression is piece-rate earning on the hour basis.

If to the expression:

$$\begin{aligned} \text{Earning} &= \text{Hours Standard} \times \text{Rate per Hour}^6 \\ E &= H_s \times R_h \end{aligned}$$

we add and subtract $H_a R_h$, then

$$E = H_a R_h + H_s R_h - H_a R_h$$

Rearranging,

$$E = H_a R_h + (H_s R_h - H_a R_h)$$

Bringing R_h outside the parenthesis,

$$\begin{aligned} \text{Earning} &= \text{Time Wages} + \text{Wages Saved} \\ E &= H_a R_h + (H_s - H_a) R_h \end{aligned}$$

This defines piece work in an illuminating way. It shows us that the worker receives in addition to time wages, all wages saved due to his working in less than task time. The expression is in the same form as the constant-sharing formulas where some fraction other than unity precedes the expression for wages saved.

SLOPES OF PIECE RATES

The slope of the piece-rate curve, like the time-rate level, depends largely on what rates exist when the new plan is installed. If the slope is greater than unity, say, 1.20, the piece-rate curve will be steeper, and if it is 0.75 the piece-rate curve will be less steep. These two slopes actually exist in the Taylor Differential Piece-Rate Plan; the rate less than unity prevails for production below task and the one greater than unity prevails above task. In case of different task levels, the rate varies inversely with the task level. The high piece rate used by Taylor, Gantt, and Merrick may be used without steps, and either with or without a day guarantee.

PIECE-RATE PLANS WITH TIME GUARANTEE

The practice of combining a time guarantee with piece rate, while desirable as a temporary expedient, removes the negative stimulus which is as powerful as the positive stimulus for mature producers. It therefore weakens a piece-rate plan. With this in view a day guarantee lower than the usual time rate is occasionally used. On the other hand, the better employees are not likely to fall back on such a guarantee, and if the production control is at all weak the full-day guarantee is necessary to make the employee feel sure of a fair wage. A combination of piece work with full day guarantee should never be called straight piece work, but rather the Manchester Plan. There are also two other names which have some justification: one, the Standard Hour Plan, and the other the 100 per cent Premium Plan.[7]

TIME BASIS OF CALCULATING PIECE WAGES

When time is used for the calculation instead of the number of pieces, the task is established in terms of standard hours of work and the rate is applied as the rate per standard hour. No matter what time is taken, the employee is paid for the number of standard hours work he has produced. This of course is giving him all of the saving or piece rate. It remains true, however, that most employees wish to know their earning per piece and will figure it when it is withheld. The time method of figuring a payroll removes one of the objections to piece rate and facilitates its use for varied production, such as jobbing. The use of the minute as the time unit furthers the same advantage.

MULTIPLE PIECE-RATE PLANS

When additional piece rates are provided for as many production zones the plans are called in general Multiple Piece-Rate Plans, and specifically the Taylor Differential Piece-Rate Plan or Merrick Piece-Rate Plan. The additional rates are particularly desirable in sales work because it is evident that a salesman has no upper limit to the amount of his "production" if he can get increasingly larger orders. As in multiple time-rate plans the steps should be ignored in the total-cost curves.

FULL SAVINGS BELONG TO EMPLOYERS

It is commonly believed that savings due to greater distribution of overhead belong exclusively to the employer because the employee has little to do with the measures which make such distribution possible. If this is true, it follows inversely that all the saving allowed under piece rate belongs exclusively to the employee because the effort of the employee is mainly independent of the management. Perhaps neither of these claims is generally accepted in practice, yet it is good psychology to follow these two principles and the tendency is now in this direction, that is, toward piece rate. Finally, it should be clearly understood that even with low slopes, piece rates give the greatest earning increments between production increments of any other plans without bonus steps, and under the multiple piece-rate plan the bonus steps may be as high as those in any other plan. When we have the slope of piece rate and the steps also, we have the most generous incentive possible for a given rate-task start.

[6] When the coefficient of this is unity, it is called "basic piece rate."

[7] A more accurate name would be the 100 per cent Constant Sharing plan.

CHAIN ASSEMBLY BLENDS TIME AND PIECE CHARACTERISTICS

Wherever there is a chain assembly, or an automatic machine, the capacity of work is known. In the case of the line assembly it is imperative that the employee keep up to this capacity. Under such circumstances the amount of production per unit of time is constantly enforced so that whether the payment plan is called time wages or piece wages, it amounts to much the same thing.

GANTT TASK AND BONUS PLAN[8]

The Gantt Task and Bonus Plan, like the Manchester Plan, is a cross between the time plan and the piece-rate plan. It is decidedly different, however, in its effectiveness because the transition from the former to the latter is by means of a high step bonus at task, Fig. 11. This not only gives a high earning location for the curve, above task, but it gives the same sharp sloping curve pointing to the origin as provided by Merrick. The plan was developed in 1901 while Gantt was working with Taylor at the Bethlehem Steel Works, and was intended as a means of upgrading men to the skill required under the Taylor Differential Piece-Rate Plan, and to be used temporarily during the installation of the Taylor methods. It was also optional.

Gantt was Taylor's associate, and an able successor in the field of scientific management. He carried out the principles laid down by Taylor in almost every respect, but far excelled him in his relations with employees. He not only put the emphasis on having the materials in the right place at the right time and in the right condition, but he felt that the employee should never be allowed to suffer in wages when these conditions of management were imperfectly realized. He believed that the incentive would be nearly as strong if he retained the Taylor plan above task, but displaced it below task by a time guarantee.

AMOUNT OF THE STEPS VARIES

While it is usual to define the Gantt plan as having a bonus of 20 per cent, he actually varied this percentage depending upon the nature of the work from 20 per cent to as high as 100 per cent where the work made great demands on employees' skill, exertion, responsibility, and endurance of disagreeable conditions. He considered 35 per cent just for general machine-shop work, and anything less than 20 per cent not sufficiently attractive to be effective. For machine tenders who do not have to do much labor or exert extreme attention, 10 to 15 per cent bonus is sufficient. For employees who have to use their eyes a great deal as in silk processes, 30 to 40 per cent is necessary. For employees who have to use a great deal of skill or who have to do heavy work in addition to skilled work, 60 to 70 per cent may be necessary.

THE DAY GUARANTEE

The substitution in the Gantt plan of a day guarantee for the Taylor punitive low piece rate below task gave a feeling of security to all employees and offset any feeling of injustice. Day guarantee is often unnecessary and even dangerous in that it allows less ambitious workers to be contented with the guaranteed amount and never really attempt their best.[9] Two circumstances made day guarantee consistent as applied by Gantt. In the first place, production control was just developing, and delays which enforced idleness were far more common than in the best-managed shops today. In the second place, Gantt did not stop with financial incentives.

[8] This plan alone is analyzed in full as an example of the formula-chart method used in the book.

[9] In England (25–75) constant sharing has been used below task. As this is between piece rate and day rate, the author believes it particularly good for beginners.

MAN-RECORD CHARTS

It was characteristic of Gantt to think of employee psychology. He recognized the employee's individuality and pride in reputation. He devised a chart which listed the men down at the left and divided the chart horizontally into units of time. This time scale was subdivided into the months of the year, the weeks, and the days. If the employee did his work in task time or less, he filled the space for that day opposite his name in solid black. If he did not, he filled it in solid red. Where the employee was temporarily placed on day work, he filled the space in with a black cross. If he were absent for a day, he indicated it by a red cross. This chart was posted and the amount of red became the measure of an individual's inefficiency. The charts are

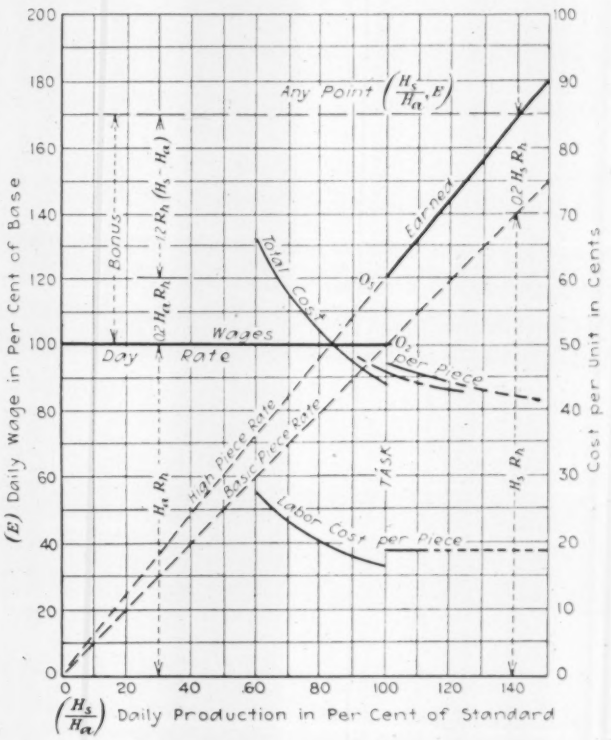

FIG. 17 GANTT TASK AND BONUS PLAN

remarkable not only in showing a preponderance of the black, but in showing a constant decrease in the amount of red as time went on.

PAINS TAKEN IN TRAINING EMPLOYEES

Furthermore, Gantt went beyond Taylor in training employees to make their tasks. In writing of this, he used the expression "habits of industry." He thought it was the employer's responsibility not only to provide work and tools, but to take every pains in developing habits of industry for all employees, so that after a reasonable time they could make the task constantly. Both Taylor and Gantt paid a separate bonus to the foremen. This of course made both the foremen and the men keep after the management to provide a continuous supply of work. Gantt even gave a second bonus to the foreman when all his men made task. This insured every pains in the matter of training. The more complex Gantt chart for progress was later used to point out shortcomings. In his last years Gantt spent his whole effort in arousing the management rather than in arousing employees, because he felt that there was much for the former to do before it could expect employees to show further increases.

The author considers the Gantt Plan both humane and strong in its financial incentive. With the use of man-record charts and proper training the weakness of the day guarantee is minimized and the non-financial feature is given equal emphasis with the financial, making it one of the most successful plans to install wherever there have been either time rates or piece rates.

FORMULA FOR EARNING—GANTT PLAN

Earning Up to Task = Hours Actual × Rate per hour

$$E = H_a \times R_h \text{ (time plan)}$$

$$\text{Earning At and Above Task} = \begin{pmatrix}\text{Hours}\\ \text{Stand-}\\ \text{ard}\end{pmatrix} \times \begin{pmatrix}\text{Rate}\\ \text{per}\\ \text{hour}\end{pmatrix} + \begin{pmatrix}20\%\\ \text{Hours}\\ \text{Std.}\end{pmatrix} \times \begin{pmatrix}\text{Rate}\\ \text{per}\\ \text{hour}\end{pmatrix}$$

$$E = H_s \times R_h + 0.20H_s \times R_h$$
$$= 1.20H_sR_h$$

The formula in an expanded form is:

$$E = \underbrace{H_aR_h}_{\text{Item 1}} + \underbrace{0.2\,H_aR_h}_{\text{Item 2}} + \underbrace{1.2\,(H_s - H_a)R_h}_{\text{Item 3}} \ldots\ldots [1]$$

The heavy line in Fig. 17 is the earning curve. Note the immediate jump or step at task so that no earning falls between 100 per cent and 120 per cent base wage.

If any point on the curve above task such as (H_s/H_a, E) in Fig. 17, be taken, the E-distance will be found to be made up of (item 1) H_aR_h, the height from the origin to the 100 per cent base-wage line; (item 2) $0.2\,H_aR_h$, the height from the latter horizontal to the 120 per cent earning horizontal; and (item 3) $1.2\,R_h(H_s - H_a)$, a variable for the height between the 120 per cent earning horizontal and the earning curve.

Shifting the origin of the curve to O_2, the corresponding vertical magnitude (item 1) H_aR_h disappears and the equation becomes, for origin at O_2,

$$E = 0.2\,H_aR_h + 1.2\,R_h(H_s - H_a) \ldots\ldots [2]$$

Similarly by shifting to O_3, (item 2) $0.2\,H_aR_h$ disappears and the equation becomes

$$E = 1.2\,R_h(H_s - H_a) \ldots\ldots [3]$$

From this position the curve may be scrutinized without the complexities of extra E-heights upon which the Gantt curve is finally built. The slope of this portion of the curve is obviously $1.2\,R_h$. This is a 20 per cent steeper slope than the basic piece rate. The production variable ($H_s - H_a$) shows that the efficiency gained is measured by the horizontal distance of the point (H_s/H_a, E) to the right of 100 per cent production.

Going through the same process on the *standard hour basis*, the formula arranged so that piece work may be isolated is

$$E = \underbrace{H_sR_h}_{\text{Item 1}} + \underbrace{0.2\,H_sR_h}_{\text{Item 2}} \ldots\ldots [4]$$

Here item 1, Fig. 17, is piece rate and the remaining item 2 must be the additional height of the earning curve above basic piece rate. As each of these items has a different slope, H_s and $0.2\,H_s$, the upper part of the earning curve cannot be parallel to basic piece rate, and the two parts of the earning curve are obviously diverging from the origin. At first Gantt did use the constant $0.2\,H_aR_h$ instead of this variable $0.2\,H_sR_h$. In that case his earning curve was parallel to basic piece rate and always $0.2\,H_aR_h$ vertically above it as in the Emerson Plan.

Equation [2], Origin O_2: $E = 0.2\,H_aR_h + 1.2\,H_sR_h - 1.2\,H_aR_h$
Equation [5], Origin O_2: $E = 1.2\,H_sR_h - H_aR_h$

but the earning E above 100 per cent day wage is the amount which we define as bonus. Therefore

$$B = 1.2\,H_sR_h - H_aR_h \text{ (Fig. 17)}$$

PREMIUM AND BONUS CONTRASTED

As far as incentive plans are concerned, the difference between a premium and a bonus is slight and a matter of association. Both are amounts of reward above time wages and may increase directly in some arithmetical proportion to production or may increase in a variable or algebraic sequence as production increases. The word "premium," however, should always be used when the wages saved $(H_s - H_a)R_h$ are divided between the employer and employee, and the word "bonus" when all wages saved are paid to the employee making the saving. Either amount may be fixed by an empiric series of efficiency points or by a formula. When in ($H_s - H_a$) terms it can be recognized by the graphical method and isolated from the whole earning formula. When applied in the negative it is called "penalty for fall down."

CONSTANT-SHARING OR PREMIUM PLANS

When wages saved due to working in less than task time are divided between the employer and employee on some arithmetical basis such as one to one out of two parts (50–50) or one to two out of three parts ($33^1/_3$–$66^2/_3$) the plan is most accurately described as a "constant-sharing plan." The original plan was called the Halsey Premium Plan. For a given arithmetical fraction of sharing, as many of these earning curves can diverge from the E-intercept point as there are task levels. The Halsey (50–50) sharing line, Fig. 12, passes through day wage at the low task while the Diemer (50–50) sharing begins 20 per cent above day wage at high task, proceeding parallel to the (50–50) sharing line which passes day wage at high task. These two plans although using the same (50–50) constant-sharing principle, are widely apart. This would of course be impossible were it not for two sets of H_s/H_a or horizontal scales which practice forces us to recognize. As the low slope of constant sharing is designed purposely to keep within reasonable earning range despite the early start of a low task, there is little to be said for such low slope when it is used to start at the latter point of high task. At least the (50–50) sharing claim means much less and undoubtedly has deceived those familiar with the Halsey low-task plan. This is made doubly clear when we observe that the ($33^1/_3$–$66^2/_3$) sharing curve passing day wages at low task, coincides with the Diemer (50–50) sharing curve at the (100, 120) point and proceeds slightly above it throughout the remaining production points. In other words, a (50–50) sharing plus a bonus of 20 per cent, but based on high task, actually gives less wages above high task than the ($33^1/_3$–$66^2/_3$) sharing with no bonus, but based on low task. The latter is a correct use of the slopes and tasks, the former an incorrect one.

LIMITS ARE TIME WAGES AND PIECE WAGES

Since the amount of sharing determines the intercept on the earning axis of the graphs when the earning curve is extended, the less the sharing ratio to the employee the higher the intercept. In other words, the limits are day wages with no premium on the one side and piece rate with full premium on the other. One-third sharing means relatively to full saving by piece rate through the low task point (62.5, 100). Like piece rate, a premium plan with no day guarantee lacks any special emphasis on its task amount of production. The relation can be understood best by an efficiency scale as in the empiric plans. The ($33^1/_3$–$66^2/_3$) constant-sharing plan with no day guarantee is an example of the correct use of the low-task, low-slope type of earning and a simple incentive for beginners.

INTERCEPTS INDICATE THE FRACTIONS OF SHARING

If the formula for the (50–50) Halsey Sharing Plan, $E = (H_s + H_a)\frac{R_h}{2}$, is written in the form

$$E = \frac{R_h H_s}{2} + \frac{H_a R_h}{2}$$

the term $\frac{H_a R_h}{2}$ becomes the vertical intercept 50 per cent day wages, and $\frac{R_h}{2}$ is the slope [half piece rate for its task point (62.5, 100)].

If the ($33^1/_3$–$66^2/_3$) sharing plan, where $E = \frac{2H_a + H_s}{3}R_h$ is expressed in the form

$$E = \frac{R_h}{3}H_s + \frac{2}{3}H_a R_h$$

the term $\frac{2}{3}H_a R_h$ becomes the vertical intercept and $\frac{R_h}{3}$ the slope (relative to low-task piece rate).

If the Diemer plan, where $E = (5H_s + 7H_a)\frac{R_h}{10}$ is expressed in the form

$$E = \frac{R_h}{2}H_s + \frac{7}{10}H_a R_h$$

the term $^7/_{10}H_a R_h$ becomes the vertical intercept, made up of ($^5/_{10}$ premium[10] and $^2/_{10}$ bonus[10]) and $R_h/2$ is the slope (relative to high-task piece rate).

This test of the intercept is most helpful in understanding all straight-line plans. The principles to bear in mind are as follows:

1 When the vertical intercept is positive, the earning can be fairly high through low production, even if the slope is slight.
2 When the vertical intercept is zero, the earning is at piece rate, regardless of slope.
3 When the vertical intercept is negative, the earning cannot be even reasonably low through low productions.

The first of these is the basic principle of constant-sharing plans and explains why they are suited to low tasks. The second of these is the basic idea of all piece rates. The third indicates why steep slopes are never suited to low tasks. There may be any number of different slopes for each starting point, piece rates diverging from the origin and premium rates from the vertical-intercept point.

SHARING PLANS DO NOT MEAN LOW WAGES

Very high wages can be put into any fractional sharing, either by using step bonuses or by starting the earning curve at lower tasks, but in any case the slope cannot keep up between production points as it does in the corresponding piece rates. The latter are decidedly more simple to figure for either the management or the men. The low slope of the premium-earning curve was just the thing to give high earning for low production and to avoid high earning if any operation chanced to be incorrectly rated.

A sharing plan can even be more generous than a piece-rate plan by starting at a low enough task location. The curve is in fact usually made to start at a low task so that it passes through a high earning field for productions below what we now call the high task. For such productions these plans may give higher wages than most piece rates, but the earning curve eventually intersects those of piece rates and is thereafter lower.

PLANS USING THE MINUTE AS THE TIME UNIT

The use of a small time unit allows a flexibility which facilitates improved operation in two respects. First, it becomes easier to assign weights to desired variations in emphasis and factors indirectly allied to production. This gives rise to the term "point plans." Second, it becomes easier to connect the rewards with production control. This actually makes of these plans whole control systems. So important are these features that a high average response is possible even when the earning curve is undeniably weak in itself or the task a little less than true high task.

Classified by the earning curves, these plans may range from the (50–50) sharing plan to piece rate. The Bedaux plan uses (75–25) sharing and the Haynes plan uses (100–0) sharing or piece rate.

The Bedaux "Point Premium" Plan distributes 75 per cent of the wages saved to the employee and 25 per cent to the supervisory force. The direct labor cost may therefore be considered constant per piece as in any piece-rate plan, but as far as the employee is concerned the earning increment is that of a constant-sharing plan and is less than that of piece rate.

The Haynes Point Plan must provide its bonus for supervisors from overhead. This is limited to $4^1/_2$ per cent of the combined earnings of the direct producers who maintain their individual performances above 60 manits[11] per hour. In other respects the plan is similar to the one already described.

The high task location for a sharing plan is partially offset by the larger proportion of the share, but there is not a great deal to be said for the Bedaux earning curve. It has a relatively low slope and begins at too high a task location to reach even as high an earning level as either the (50–50) or the ($33^1/_3$–$66^2/_3$) Halsey earning curves which start through the lower task. The merit lies entirely in the method of keeping track of work. The work per unit of time, in this case a minute, becomes a common denominator for all performance in the company.

THE UNIT DEFINED

The amount of work per minute, together with its proper allowance for fatigue, is the unit of production and is established for each job. The unit consists of a fraction of a minute of effort plus a fraction of a minute of compensating relaxation, always aggregating unity but varying in proportion according to the nature of the strain. In other words, it corresponds to the effort developed by an "average person" working under normal conditions at a normal rate of effort for one minute of time. It is carefully set so that 60 units is task, and 80 units is considered average for select and seasoned employees.

HOW THE UNIT IS USED

The number of units produced by individuals or by machines is posted daily beside the number of units standard. A foreman can at once tell what individuals are below standard and how much they are below. Similarly a weekly recapitulation sheet enables each superintendent to compare the efficiencies of his foremen, and the manager to compare those of his superintendents. Comparison can even be made between the various plants of a large company, and for this reason the plan has been installed in some of the largest companies. The performance can also be given in dollars so that a manager can point out to his superintendent or foremen how much they might have saved each week if they had prevented this or done that. It has brought about better

[10] Historical use of the terms.

[11] A "manit" is equal to a standard man-minute of work.

production control and better unity of all management controls than have most other plans. It obviates the danger of expecting too much from the wage incentive itself without proper production control, or of having a strong production control which takes no account of the labor aspects.

VARIABLE-SHARING PLANS

When the wages saved due to working in less than task time is divided between employer and employee on some algebraic basis such as the ratio of hours saved to hours standard, the plans are most accurately described as variable-sharing plans. The Rowan Premium Plan divides its premium in the manner just indicated.

Carl G. Barth, an associate of Taylor, conceived the idea of designing a wage plan which would have an earning curve similar to the Rowan plan, but extending all the way to the origin. He took wage elements and combined them in a way that would give the hyperbolic type of curve. In short, he multiplied hours standard by hours actual and took the square root of the product, multiplying the result by the rate per hour. This substitutes the geometric mean for the algebraic mean used by Halsey. The earning curve rises rapidly through low production and approaches the straight line for higher production with less slope than the Halsey straight line. It avoids the time guarantee and passes through the low task point, so that even for high production it gives a fair earning. The fact that it is one of but four earning curves below task to pass through the area between time wages and piece wages, makes it important for employee beginners. Even with the radical the formula is quite simple for all points of production, but it is meaningless to those who do not appreciate the mathematical necessity of its form, and that is impossible to explain to most employees.

EMPIRIC BONUS—EFFICIENCY PLANS

When points of production-earning are selected on the chart regardless of any natural law and the earning curve drawn through them, the plans are best described as empiric plans. The earnings of such plans are calculated and explained by two-column tables, one column for efficiencies of performance and one for bonuses to be awarded in addition to the guaranteed day wages. Usually the empiric points extend only through a narrow production zone such as $66^2/_3$ per cent task to 100 per cent task. If the earning curve is at 120 per cent base wages at the end of the empiric portion, the piece rate for that point (110, 120) may be used for all earnings above task as in the case of the Wennerlund plan, or a straight-line curve may be used parallel to basic piece rate as in the case of the Emerson plan. The earning formula for this plan above task appears to give all of the wages saved and a bonus besides. It does actually do this relatively to the point (100, 100), but it does not do it relatively to its own starting point (120, 100).

This will readily be seen by comparing the Emerson earning curve with the Gantt earning curve. Both begin at the same earning point for high task, that is, 120 per cent base wages. The Emerson earning curve above task is exactly what Gantt first used and then discarded for the (100, 120) piece rate. The present Gantt curve has the true piece-rate slope for its starting point and would lead to the origin if extended. The Emerson curve, while parallel and above the basic piece rate, does not have the true piece-rate slope for its starting point, and if extended will be seen to have an intercept of 20 per cent on the earning axis. The mathematics of this curve is most interesting and does much to explain the inconsistency just outlined. In fact, it may seem strange but it is nevertheless true that an earning curve which starts at a point above that of basic piece rate must have a greater slope than basic piece rate in order for it to give proportional increment in earning for the increments in production.

PRINCIPLES FORMULATED FROM THE ANALYSIS AS A WHOLE

Principles concerning the separate plans have been formulated as the separate plans have been analyzed. Let us now analyze the plans as a whole in the hope of formulating principles for the whole.

First, we have seen that both the task location and the base-time wage level may be changed, making it possible for these earning curves to reach almost any position on the chart. It is equally evident, however, that we cannot safely give a high earning for low production on any piece-rate plan and we are not likely to give a high earning for high production by the less-than-unity slopes of the sharing plans. One of the tests of a well-designed plan is then the suitability of task to slope as already indicated. We know the employee is interested in the whole earning curve because he may be at different productions on different days, but it is equally clear that the employer is mainly interested in the single point or narrow range of points at which a given plan will hold the average production day after day. In fact, no other points on the direct-labor-cost curve have anything to do with overhead cost in practice. The "departmental response point," as this is called, varies between the plans and for a single plan in different installations, but it varies little from day to day for any one plan under one set of labor and managerial conditions. Naturally we desire this point to be fairly high on the production scale, and we may think we desire it fairly low on the earning scale. When we remember, however, that as an incentive to the employee the amount of earning becomes psychologically the independent variable and that his production is a response, we shall admit that we cannot have our cake and eat it, too. We must concede high earning in order to obtain high production.

INCENTIVES REDUCE TOTAL COST RATHER THAN LABOR COST

We can truly combine higher individual earning and lower unit labor cost by eliminating waste labor through improvements in machinery, methods, or control. By this means we may eliminate motions, sub-operations, or whole jobs and secure the same net results with fewer "kilo-man-hours." We cannot, however, raise earnings and at the same time lower unit labor costs any other way. Employee assistance to this process may come as the result of an incentive, especially if it is a group plan, but such a result is incidental and not a major expectation. In comparing any two individually applied incentive plans it can usually be ignored, that is, an incentive plan is an operating mechanism. We must consider the job standards as already improved and fixed. In these circumstances it is a flat contradiction to speak of lowering labor costs simultaneously with raising wages; they are practically one and the same. If we say total costs, there is no contradiction. Overhead is affected very little, usually not at all, by the installation of a strong incentive as compared with a weak incentive.

Stated as an economic principle this would be: When one incentive succeeds in holding the average production response at a higher efficiency than another incentive, the nearly constant overhead is distributed over more units and the overhead per unit is reduced. Consequently the total cost per unit between two such plans may be (*a*) equal despite different direct labor costs per unit, or (*b*) less in the case of the one having the greater direct labor cost per unit. Were it not for this principle there would be no incentives other than day rates, and those would always be as low as possible. The principle has given rise to the many incentive experiments, and in truth embodies the very essence of the incentive idea. Designers of incentive plans are

all groping for the incentive that will successfully hold the maximum number of employees near the maximum productions of which they are capable. All factors in a department and all employees involved must be considered over a period of weeks in estimating the merit of a plan.

Final Test of an Incentive

Since an incentive plan is best only in the light of the conditions which it must fit, we must be certain that its effect will be consistent with all policies of the company. This may be tested by having a management committee apply the Dennison classification to the given conditions. This classification was given by H. S. Dennison as a paper before the winter convention of the American Management Association, New York City, February 7, 1928, and at that time was put into diagrammatic form by the present author. There are two main divisions of incentive characteristics and corresponding policies of management. The policy "A" is that of immediate stimulation of effort, emphasizing the "star" performance, and is usually adaptable to the small, non-continuous processes. The policy "B" is that of long-run stimulation of team work, emphasizing organization performance, and is usually adaptable to large continuous processes where jobs are interdependent to a high degree. These two major policies are divided into seven subdivisions which occur as contrasting conditions of the policies.

Similarly we must consider the apportionment of weights to the fundamental interests which will assure each one its proper emphasis. There are three of these fundamental interests connected with every job: (*a*) quality of work, (*b*) quantity of work,[12] and (*c*) economy in the use of materials. The relative importance of these fundamentals varies widely, and a requirement of a well-determined wage incentive is that it shall correctly reflect the relative importance of all three. Like rate setting, the fundamentals of quality, quantity, and waste can only be understood by thorough job study. It is evident, therefore, that little should be expected of any incentive until job standardization has been used to establish standards for all of these and related matters.

Installation of Plan

A conference should be held in which employees are allowed to express their point of view. When numbers are large, department groups or even operation groups may be consulted separately. There should be no great haste in the matter. A plan once selected must be put into operation gradually. A small beginning is wiser than an extensive one. Leaders among the employees who are intelligent and influential should be put on the new plan first. These leaders, when convinced of the plan's merits, will bring their friends to desire the same advantages. If a plan will not work with a few it will not with many. Failure may forfeit much of the benefit anticipated from expensive job standardization and rate setting. In this matter of caution it seems timely to add that the group application of incentives is now passing through the same stage of experimentation that the individual application passed through a generation ago. Much trouble will be avoided if employers will refuse to accept any incentive proposal until the principles are clearly seen. The group application has a growing place in industry but it should not be extended beyond moderate-sized groups of interdependent operations. There is no place for high-pressure salesmanship in these matters. Enthusiasm for a new or easy device must give place to slow analysis.

[12] L. P. Alford has expressed the relationship between tasks and incentives in three concise laws. See his "Laws of Management," p. 190.

The Centenary of Thomas Young

HIS name familiar to every engineer through the term "Young's modulus," Dr. Thomas Young, who died at Park Square, London, May 10, 1829, a hundred years ago, was considered by no less an authority than Rankine as "the most clear-thinking and far-seeing mechanical philosopher of the nineteenth century, and one of its most accomplished and profound scholars."

The tenth and youngest child of a Quaker land owner, Young, was born at Milverton, Somerset, June 13, 1773, and from the first gave evidence of extraordinary ability. As a boy he was familiar with not only Latin and Greek, but also with Hebrew, Persian, and Arabic; as a youth he read and digested the whole of Newton's "Principia;" as a student he read a paper to the Royal Society on the muscular fibers of the eye, and at 21 was admitted a Fellow of the Society. From St. Bartholomew's Hospital he went to the Universities of Edinburgh, of Göttingen, and of Cambridge—being known at the latter as "Phenomenon Young;" and then in 1801, at the age of 28, became professor of natural philosophy in the newly founded Royal Institution, where Davy was his colleague. It was there, in the course of the next two years, he gave his courses of lectures which in 1807 were published under the title "A Course of Lectures on Natural Philosophy and the Mechanical Arts."

The lectures themselves had proved too abstruse for the fashionable audiences which flocked to hear Davy, but the two quarto volumes proved a veritable gold mine for subsequent writers and investigators, and Rankine, sixty years later, described the work as "the best existing compendium of the elementary principles of physics." It was Young who first introduced exact definitions into the study of the strength of materials and elasticity, and he it was who gave the term "energy" its present significance. His discoveries in sound and light were of fundamental importance. The science of optics, except as it referred to the construction of telescopes, made little advance in the eighteenth century, but it was Young who explained the phenomenon of the interference of light and revived the undulatory theory first enunciated by Huygens. Fresnel's epoch-making work was contemporary with that of Young, but independent. But physical science claimed only a part of Young's time. His mind, cast in no ordinary mold, turned with ease from one difficult subject to another. From the study of bridges he would pass to that of the motion of the blood; from the investigation of the tides to the deciphering of Egyptian hieroglyphics. He made calculations for an insurance company; he was for years physician to St. George's Hospital; he superintended the Nautical Almanac; and he sat on committees on shipbuilding, on the use of gas, and on weights and measures. In capacity for intellectual work, in retentivity of memory, in powers of understanding, such men as Young stand apart, though he himself, curiously enough, considered that other men by concentration could do what he had done.

There is a tablet to Young in St. Andrew's Chapel, Westminster Abbey, while in the Shire Hall, Taunton, in his native county, there is a bust bearing an inscription in which he is described as "unsurpassed in the extent and accuracy of his knowledge, second only to Newton."—*Engineering*, May 10, 1929, p. 589.

Recent Developments in the Mechanical Loading of Coal in Mine Cars

Difference Between Surface and Underground Loading Problems—Classification of Loading Machines—Conveyors and Scrapers—Machine-Shop Practices—Labor and Mechanization—Financial Aspects of Mechanical Loading

By O. G. SHARRER,[1] SUPERIOR, WYO.

THE application of machinery to coal mining is not a new thing, as many persons think, but has been going on for many years, and instead of being the very last one in industry to adopt machinery the coal miner has pioneered many mechanical applications. Good, practical machines were long ago designed and applied to pumping, hauling, ventilating, and finally to undercutting and drilling for explosives, but the most arduous of the miner's tasks, the actual placing of the coal in the mine car, remained a hand operation until very recent years.

The recent development of mechanical mining has been so rapid and covers such a variety of phases that a paper dealing with the subject as a whole would be entirely too voluminous. The present paper has therefore been confined to mechanization in the Rocky Mountain district in general, and the Wyoming field in particular.

To the layman the mechanical loading of coal appears to be a very simple matter, and it is often pointed out that there are a multitude of machines that will handle almost any kind of material, these machines having been used on the surface for many years. The question is often asked, "Why not simply take one of these machines underground and put it to work?"

Unless one has put in some time underground it is impossible to understand why some things which are simple on the surface become absolutely impossible in a coal mine.

A large stock pile of coal on the surface may be attacked by any one of several machines and moved easily, but underground the problem is quite different. For example:

Large piles of coal cannot be assembled underground for a variety of reasons. In many cases a few tons are all that can be obtained in one place during an eight-hour shift, and this means that a machine must be very mobile or, if remaining in one place, must be idle a large part of the time.

Spaces are restricted to fixed dimensions and cannot be increased except at enormous expense and much danger to workmen.

Even with the best of mining skill and material there is the ever-present danger of sudden falls of overburden or sides of excavations, with the accompanying hazard of having expensive machinery buried and ruined.

Adequate illumination of working places in coal mines presents a problem which, while considerable progress has been made, is still far from being solved. The more intense the illumination the more pronounced the shadow, hence rapidly moving machinery cannot be observed and workmen usually depend more on hearing than on vision in determining whether a machine is functioning properly.

Ventilation is a constant source of trouble. Every cubic foot of air must be literally pumped into the mine, and it is very difficult to supply adequate quantities to all confined spaces.

The atmosphere in a coal mine is always liable to become laden with explosive matter which will detonate with terrific violence upon contact with a very minute spark. This condition makes the use of electric motors and rapidly moving mechanical parts a very dangerous operation unless extraordinary precautions are taken.

Lastly, coal mining is rather unfavorably placed in that it is the only industry which is completely hemmed in by laws. Each state has its own code, and no attempt has ever been made to make the various laws uniform. Often what is perfectly legal in one state is a violation of the code in another. This applies particularly to the laws relating to blasting: in some states shots may be fired at any time during the twenty-four hours, while in others shots may be fired only when all men are out of the mine.

Where blasting is permitted at any time, coal may be prepared as needed, and any type of machine is always assured of a sufficient supply of coal. Where blasting is permitted only during the off-shift period, only the more mobile types of machines can possibly succeed, for a machine must be equipped to move quickly from place to place in order to handle a tonnage large enough to give any economy in operation.

A machine that will fabricate an automobile part will work as well in California as in Michigan, but a coal-loading machine that works very well in Wyoming may not have a chance of success in Utah due merely to restrictive legislation. It may be pointed out, however, that coal dust, methane gas, explosives, etc. behave in exactly the same manner wherever they are encountered, and it would appear quite feasible to make the various state mining codes more uniform without sacrificing anything vital to safety.

Classification of Loading Machines

In order to simplify the discussion of loading machines it will be advantageous to classify them in such terms as will be more or less descriptive of their capabilities. All mechanical loaders fall naturally into one of three main classes as follows:

Class 1—The Complete-Cycle Machine. This is a machine that performs the entire operation of moving the coal from the mine floor into the mine car.

Class 2—The Part-Cycle Machine. This machine performs only a part of the operation previously done by hand.

Class 3—The Complete-Cycle Mining and Loading Machine. This machine breaks down, transports, and loads the coal from the solid face into the mine car.

These three main classes can again be subdivided into the following sub-classes which are descriptive of their method of operation:

A—The Mobile Complete-Cycle Machine. This machine is fitted with track wheels or tractor treads and can quickly move from place to place.

B—The Stationary Complete-Cycle Machine. This machine

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Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

is fixed in a stationary position and is not moved until a definite mining unit is worked out.

The mobile complete-cycle machine measures up to the layman's idea of coal-loading machinery because it can get from one place to another easily and performs its duties in a very thorough manner. In the design of these machines two general principles have been followed. One type of machine (Fig. 1) simulates the action of a hand shovel, having a large shovel or dipper which is forced into the coal pile by power and lifted and emptied into the mine car.

These machines are very simple and sturdy, and will move a

FIG. 1 SHOVEL LOADING TOP COAL

FIG. 2 SHOVEL ADVANCING ROOM FACE

very large tonnage where conditions are suitable. They have the advantage that they will buck and tear down a stiff coal pile much better than any other type. Their mobility is very good and the operation simple. They all require too much head room to permit their use in low seams, and the arc of swing forbids their use under roof requiring heavy and close timbering. In common with all types of mechanical loaders these machines make it very difficult to remove impurities underground, and where bone or rock bands are present they must be removed by an arc wall or slabbing machine before the coal is blasted if a clean product is essential.

The second type of mobile complete-cycle machine (Fig. 2) employs the principle of a gathering head consisting of arms, rotating shovel, or other device which rakes the coal on to a flight conveyor that transports it into the mine car.

These machines function very well and are loading very large tonnages in various parts of the country. They are particularly valuable where blasting is not permitted during working hours, as their ability to move quickly permits loading out a large number of places during one shift. They occupy considerable space and cannot work successfully where close timbering is required or where the coal is less than five feet in height. While the cleaning of impurities is very difficult, it can be performed somewhat better than by the shovel types previously described.

The greatest weakness of this type of machine is its multiplicity of parts and complication of assembly, which causes high maintenance cost. In justice to the manufacturer it must be admitted that these machines have been very much simplified in later models, with a corresponding decrease in maintenance cost.

Where the conditions are suitable for their operation, that is, say, 7 to 8 ft. of clean coal with good roof and favorable pitches, these machines are in command of the field at the present time. Fig. 2 shows one of these machines in a high coal mine.

FIG. 3 SHAKING CONVEYOR WITH AUTOMATIC SHOVEL HEAD WORKING UNDER TENDER ROOF

Class 2 comprises machines which perform only a part of the operation of loading coal into a mine car, and these machines so far have been made to perform two separate functions. In one case the effort of lifting the coal to car height is performed mechanically, and in another the lifting as well as the transporting of coal from a distant face is performed by mechanical means.

This type of machine performs only one part of the operation of loading coal from the floor into the pit car, the particular function of the various machines in this class being to eliminate some part of the arduous manual labor involved in this operation.

One very difficult step in the mining of thin seams has been the moving of coal from the actual mining face to a main roadway where it can be handled by some form of mechanical haulage. If the car is to be taken to the face, a large amount of roof or floor rock must be handled in order to give sufficient height. The cars must be handled either by men or animals, with a very large and inefficient expenditure of energy.

The various types of conveyors have been designed particularly to handle this situation, and they have done very well.

Several different types of conveyors are now being used for this work, and the systems devised have made the working of thin seams possible.

By concentrating a large production from a small area, ventila-

tion, haulage and supervision have been very much simplified, with corresponding reduction in costs. These concentrated systems of mining have proved to be much safer than old hand-mining methods, largely because of the ease of supervision.

Investment charges on this type of machine are not large, and maintenance costs are unusually low owing to the simplicity of construction.

In the speeding up of haulage the tendency has been to go from large to still larger cars. These cars have been made longer and higher until the work of lifting a shovelful of coal manually from the floor of the mine over the side has become a very severe task.

This has made a definite place for a part-cycle machine which is merely an elevator and which at first glance looks like a rather superfluous piece of equipment. However, when one considers the difference in energy expended in lifting a ton of coal the three additional feet necessary to put it over the side of the pit car as against the energy needed to put it on a conveyor eight inches off the floor, it is apparent why these machines have become so popular. In addition to conserving the energy of the workman they permit the organization of the work along efficient lines.

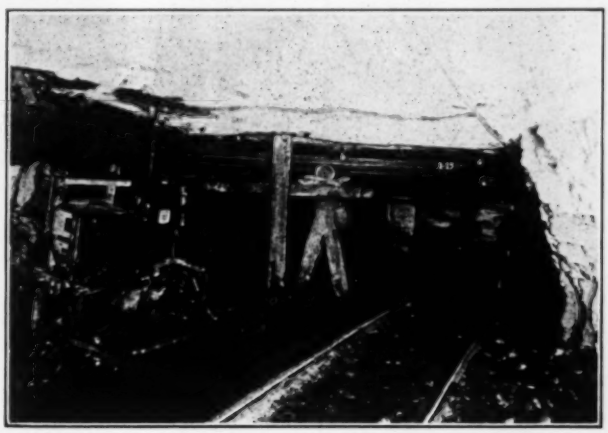


FIG. 4 LOADER HEAD SHOWING LOCATION OF REMOTE CONTROLS

Many different types of these machines are now being made, all on the same general principle.

The entire machine is very light and can be moved easily by two men. No change in mining system nor any particular skill is needed in the use of these machines, so they provide a very efficient tool for introducing mechanical methods into a hand-operated mine. Pillars can be recovered very successfully and lump coal is increased, for these machines handle large lumps very well. The blasting can be closely supervised.

SHAKING CONVEYORS

Shaking conveyors are in a special class by themselves, as no other machines work in a manner in any way similar to them.

Without any loading device attached to them they are stationary part-cycle machines, performing both operations of transporting and lifting the coal to car height. When equipped with an automatic shovel head they become stationary complete-cycle machines and do their duty very well.

These machines were developed in Europe where they have been used in thin-seam, long-wall work for many years. Little consideration was given their use in America until very recently, and they were introduced only as an auxiliary method of transporting coal from the face in low seams. Their use in concentrated mining systems followed in a short while, and finally the automatic loading head was devised. This automatic loader was a characteristic American innovation and has made a very practical complete-cycle loading machine. (Fig. 3.)

Pan shapes, connections, methods of support, etc. were copied from European practice, and only recently have these machines started to evolve along lines suitable to American conditions.

The theory of coal transport by means of reciprocating troughs is an exceedingly complicated matter, a very large part of the problem not being susceptible of mathematical analysis. It was proved at a very early stage that engines designed according to European practice, where comparatively short pan lines were used without any automatic loader head, were not suitable for

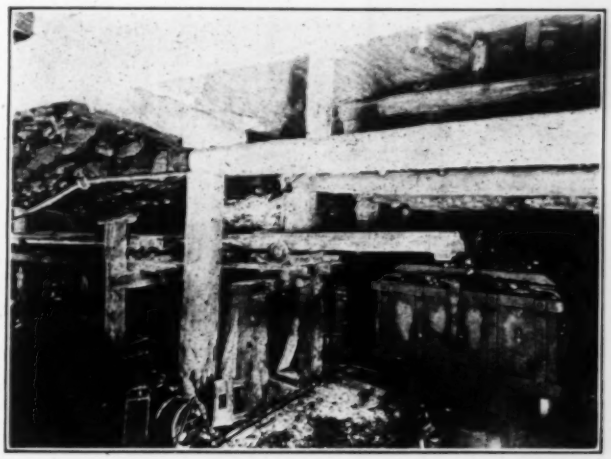


FIG. 5 TYPICAL CONVEYOR LOADING HEAD

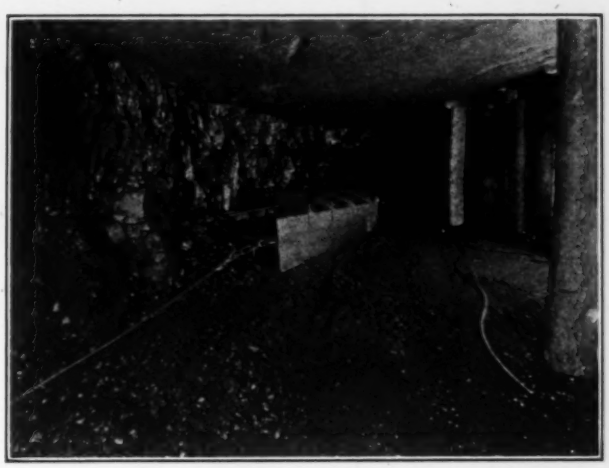


FIG. 6 LARGE SCRAPER ON LONG FACE

American conditions, particularly where automatic shovels were employed.

There has been a very radical departure from the original design in the new engines built by American manufacturers, and these are much more suitable than those first used. (See Figs. 4 and 5.)

SCRAPERS

Two general classes of scrapers have been developed up to this time, each to serve different conditions.

The small scraper was a pioneer loading device and is still very popular where conditions are suitable. This machine will work very well in thin seams that are reasonably clean, and where wide

rooms can be driven or long faces held open it is a very economical machine. The small scraper comes under the mobile complete-cycle class, and with its ingenious sheave arrangements can be used to advantage even for entry driving.

The large scraper was designed for heavy tonnage from a small area at times of peak demand, and has worked very well where roof and floor conditions are suitable. The Union Pacific Coal Company is believed to hold the record for tons produced by one

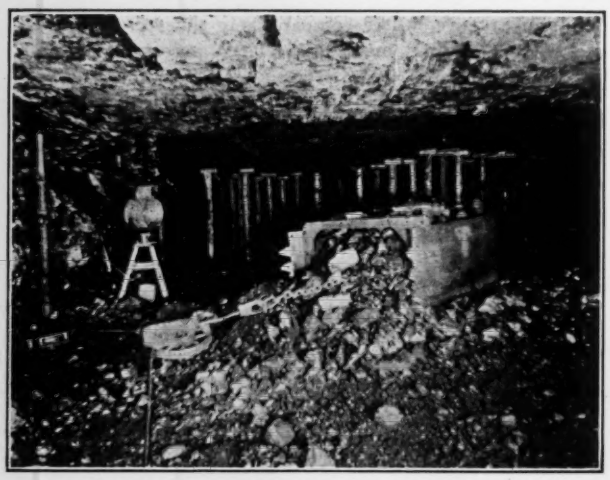


FIG. 7 HEAVY-DUTY SCRAPER READY TO TURN CORNER

FIG. 8 PICKING SLATE ON CONVEYOR LINE UNDERGROUND

loading unit, a scraper with a crew of 19 men having loaded 768 tons in eight hours.

This loading method employs a 125-hp. hoist having two drums and is driven by a 2300-volt induction motor. The scraper (Fig. 6) is of $3^1/_2$ tons' capacity and is moved by $^7/_8$-in. steel rope. Coal is moved from the long face on to a belt conveyor which discharges into a lateral conveyor for trip loading. This use of steel rope is the most severe the author has ever seen (Fig. 7), and the rope manufacturers are to be congratulated on the quality of ropes produced for this service.

Scrapers cannot be worked where heavy roof requiring close timbering is encountered, and the large tonnages produced require an enormous amount of development work. They cannot be provided with this development unless entries are driven mechanically, and it would be useless to attempt their installation without some mechanical system of entry driving.

The Union Pacific Coal Company uses these machines to meet the peak demand for coal which occurs in August, September, and October. During the slack period entries are advanced by shaking conveyors and duckbills working double shift, and when the heavy demand arises all scrapers are put to work at full capacity until the run is over. These scrapers then work part time and are completely overhauled in preparation for the next period of heavy demand.

Even allowing only ninety days use each year they show good economy, for their large capacity makes the capital investment per ton very low, and they permit the coal to be stored in the mine, thus saving all storage and handling expense.

If properly used they do not break the coal as much as one would expect; in fact, the lump percentage compares favorably with that obtained in hand mining if proper care is taken in blasting.

The foregoing covers in a general way the various types of

FIG. 9 SHAKER CONVEYOR UNDER HEAVY ROOF

machines which have proved successful, but does not cover the multitude of machines that are in the experimental stage.

Each of these machines is best suited to some one particular condition of seam, and selections should be made accordingly.

In reasonably high seams with good roof and fairly regular operating time, the large mobile complete-cycle machine has no competition, especially where blasting is permitted only once a day.

Where conditions are favorable and periods of peak demand are the rule, the scraper is a very efficient tool.

With heavy roof, deep cover, or low coal the shaking conveyor equipped with a duckbill has no competitor, for these machines will work seams that cannot be mined by hand mining methods. (See Figs. 8, and 9.)

MACHINE-SHOP PRACTICES

It is usually the case that a shop and mechanical force perfectly capable of dealing with a hand-loading operation proves inadequate for the same tonnage when mechanically loaded.

The coal-mine mechanic of the old school was a good, hard-working man, but those of his kind who could be really classed as journeymen were very scarce. A foot rule was his only measuring device, and micrometers, surface gages, etc. meant nothing to him.

When the mechanical loaders came in he found he was beyond his depth at once, for the assembling and repairing of these machines requires mechanics of a very high order. This applies to mine electricians as well, for the application of electricity to coal mining has become very technical.

The planning of a shop and the organization of the mechanical and electrical forces of a mechanized property are a large problem in themselves, and naturally must be worked out to suit the needs of each particular operation.

An arrangement of personnel and practice that is working very well at an operation producing 2500 tons per day is as follows: One journeyman mechanic who does bench work almost exclusively; one journeyman mechanic who does assembling and adjusting along with some bench work; one pipe fitter and handy man; one machinist's apprentice; one journeyman blacksmith capable of heavy forge work and welding; one blacksmith's helper; two journeymen welders capable of using acetylene, electric, and carbon arc; and one master mechanic in charge of machine shop and underground repair men.

In the electric shop there are one armature winder, two journeymen electricians, two electrician's helpers, one electrician's apprentice, and one chief electrician who has charge of all electrical work both in the shop and in the mine.

In addition to the regular shop force each mine has a force of repair and maintenance men working under a machine boss who reports to the mine foreman.

The master mechanic and chief electrician are in charge of methods and practices underground in their respective spheres.

This is a considerably larger force than would be used for a similar tonnage which is loaded by hand, but such a force is necessary to care for the emergencies that arise when many loading machines are in constant operation.

Naturally there is not enough repair and assembling work to keep such a large force of men constantly employed, and as competent workmen will not remain where employed only part time, some system had to be devised whereby these men could be given reasonably steady employment upon work that could be justified economically.

Efficiency engineers have discussed from all angles the question of making various machine parts at a local machine shop, and the consensus of opinion appears to be that this making of parts locally never pays. Our experience along these lines, however, proves that this opinion is not correct. With standard shop equipment certain machine parts can be fabricated as economically in one place as another, slight differences in wage scales being in many cases offset by freight and handling charges. Unit costs are here of course affected by several factors and it requires considerable study to ascertain facts from all angles, but we believe the plan we are now using to be economically sound. When it is desired to ascertain whether or not it is economical to make any part of an apparatus in our shops, the master mechanic or chief electrician, as the case may be, prepares a bid as carefully as he would if he were in the contract business. This bid is then compared with current inventory prices for comparison, and if it is apparent any economy can be obtained, the mine superintendent approves a trial run of this particular part. The piece is then put under work and completed, careful record being kept of actual cost.

Many ingenious methods of reclaiming machine parts have been devised by our mechanics since their interest has been aroused in such matters.

No attempt is made to make all repair parts in a local shop. Certain lines in which good economy can be shown are selected, and merely enough of these parts are made to keep the force employed steadily, parts in excess of what can be made in the local shop being purchased on the open market. One would naturally expect that this practice of making repair parts would not be looked upon with favor by machinery salesmen, but, strange to say, sales engineers have without exception taken a very friendly interest in our amateur attempt at manufacturing.

Several men who are experts in their line have spent hours in local shops helping to iron out little difficulties that arise from time to time. These men of course are not forgotten when new machinery is purchased, and the time spent on the ground with the maintenance men permits them to see the problems through the user's eyes.

Considerable economy has been obtained through the salvage and reclaiming of broken and worn-out equipment. All such material is collected in the mine and sent out at regular intervals. When it reaches the surface it is sorted carefully by outside laborers; scrap copper, brass, etc. are barreled for shipment, and parts which are usable are boxed and sent to the shops where they are stored for reclaiming. This provides employment for aged and crippled employees, and shows some very substantial savings as well. Only the surface of this particular phase has been touched, and with further study some astonishing results can be obtained.

LABOR AND MECHANIZATION

Mechanical loading is not a panacea which will cure all the ills that plague the coal industry. Even with perfect machines and the wisest management the problems that remain are staggering.

The problem of overproduction is not in any way affected by mechanical loading unless uneconomic mines are closed.

Mechanical loading machines contribute to unemployment, for there is no avoiding the fact that the introduction of a machine that allows one man to produce as much coal as was formerly produced by two is going to throw one of these men out of a job. This question has been avoided in most discussions of mechanization, but when the full extent of a problem is known the first step in its solution is quite often apparent. Granting that mechanization is rapidly forcing men out of the industry, what can be done about it?

Employers in the past felt no responsibility to their employees once their payroll was met, but modern economic thought insists that the responsibility of the employer extends beyond the mere payment of wages. No people can be prosperous with a large percentage of their man power unemployed or working at a starvation wage. Any great change in industrial practices is always accompanied by unsettled conditions, and at the present time American industry is going through the most rapid changes ever encountered in history and it is impossible to avoid some unemployment.

The complete solution of this problem appears impossible at this time, but the coal operator need concern himself only with his particular part of the question, and here much can be done to make adjustments without throwing undue hardships on any community. The duty of the employer to his miners is very clear and presents no insurmountable difficulties in the majority of cases. In the experience of The Union Pacific Coal Company the number of employees dropped from 3034 in 1923 to 1838 in 1928, and it would be natural to suppose that 1196 men were thrown out of work, but this has not been the case. These 1196 men were simply allowed to drift away at their own volition without hiring any replacements. There are natural depletions of working forces around a mining plant that operate very rapidly when no new men are employed. Some men acquire a competence and retire, others just drift to new locations. The mining villages of the West have sent many young men and women to the universities, and when they have completed their education these young people never return to the mines. This phase of the situation is not desirable, and the attempt is now being made to retain the interest of these young people in the coal-mining industry. Lastly, aged employees are retired on pension when their usefulness is terminated, so that there has never been the fear and suspicion of the new machines which has been characteristic in many cases. Men now prefer employment on mechanical loaders to

TABLE 1 DATA ON INVESTMENT AND OPERATING COSTS OF MECHANICAL COAL-LOADING INSTALLATIONS

	Year					
	1923	1924	1925	1926	1927	1928
(1) Total number of employees[1]	3034	2770	2486	2241	1915	1838
(2) Percentage, using year 1923 as 100 per cent	100	91.3	82	73.9	63.2	60.7
(3) Decrease in number of men (total)	.....	264	548	793	1119	1196
(4) Yearly decrease in men	.....	264	284	245	325	77
(5) Total coal loaded (system), tons	3,241,104.85	2,821,677.80	2,779,064.54	2,776,245.45	2,750,430.20	2,927,390.00
(6) Mechanically loaded coal (system), tons	107,693.00	161,245.00	265,432.00	601,611.15	1,107,775.85	1,501,578.00
(7) Percentage of mechanically loaded coal	3.2	5.7	9.6	21.7	40.3	51.3
(8) Total capital expenditure to date for mechanical loading machines[2]	$41,705.23	53,236.32	77,347.53	206,128.70	327,292.44	429,392.98
(9) Net investment after depreciation	$23,349.77	28,434.68	34,026.19	144,742.48	217,410.69	259,232.97
(10) Yearly purchases of new loading machines	$11,427.22	11,531.09	24,111.21	118,593.97	121,163.74	102,100.54
(11) Tons per dollar of original capital expenditure for mechanical loading machines, (6) ÷ (8)	2.58	3.03	3.44	2.92	3.38	3.50
(12) Original investment per ton of mech. coal, (8) ÷ (6)	$0.387	0.330	0.291	0.343	0.296	0.286
(13) Original investment per ton of mech. coal after depreciation, (9) ÷ (6)	$0.217	0.177	0.128	0.241	0.197	0.173
(14) Ratio of total payroll cost, per cent[3]	100	92.8	87.2	83.5	75.1	71.7
(15) Ratio of mine cost per ton, per cent[4]	100	93.7	86.7	84.1	72.2	75.7
Number and types machines purchased each year	2–4 B. U. Joys 4 Thews	2–4 B. U. Joys	8–4 B. U. Joys 1 shaking conveyor	6 shaking conveyors 8 scrapers	2 Butler shovels 30 shaking conveyors	5–5 B. U. Joys 12 shaking conveyors 6 pit-car loaders

[1] Exclusive of general office.
[2] Investment in 4 Thews prior to 1923.
[3] Includes all general-office payroll.
[4] Includes all labor, material depreciation, depletion, etc.

working in hand-loading mines, for they find the work easier and safer, with practically steady time throughout the year.

Financial Aspects of Mechanical Loading

In the final analysis of any new departure in industry the financial returns are in reality the determining factor as to whether or not the new method will survive. Much harm has been done the new methods of producing coal by claims that are entirely too extravagant, such claims being based on more or less incomplete data. Cost accounting and cost records have not been very accurate around coal mines in the past, and even now many large producing companies have records which are very incomplete and in many instances dangerously misleading.

The Union Pacific Coal Company has always had fairly accurate cost records, but upon the inception of mechanical loading it was realized that ordinary coal-mine accounting was totally inadequate and a very careful study was made by the engineering and accounting departments of the cost methods used in other industries. It was soon determined that the mines needed a system quite different from those in vogue where standard products, upon which unit costs are easily found, are made.

The accounting department, working with the engineering force, devised a system of accounting which takes into consideration the various factors of mechanical mining and which shows accurate unit costs for each operation. This system, while far from being perfect, does give an accurate financial history of every mechanical unit, and prevents the chance of being deceived as to the performance of any machine or system of mining.

Table 1 is the correct financial history of The Union Pacific Coal Company's mechanization program from 1923 to 1928, inclusive, and is self-explanatory. The savings shown are not as spectacular as some which are claimed by mechanical-loading enthusiasts, but they are quite substantial, especially when one bears in mind the fact that during the early years 1923–1925 the work was very largely experimental.

Any one mechanizing at the present time can take advantage of all the experimenting done in the past, and should be able to improve upon these figures to a large degree.

Many outside factors, such as market, continuity of working time, kind of labor, etc. complicate the problem very much, however, and one can make no predictions except where all these factors are accurately known.

There are many invisible financial advantages which cannot be accurately outlined, but which represent a considerable saving. For instance, it will be noted that in 1923 the total number of employees was 3034, while in 1928 this number had fallen to 1838. This is a very important factor where towns are maintained by the employer, as it cuts the investment in housing facilities practically in direct ratio to the number of employees. Coal can be mined at greater depths mechanically than by hand, and this makes an increase of many million tons available at each loading plant.

Mining areas for required production are very much smaller than in hand mining, with proportional reduction in overhead costs.

It must be borne in mind, however, that these intangible savings are not immediately available when an old hand plant is mechanized, and it is not until the mechanization program has been in force for quite a period of time that they are noticeable.

In order to get best results from mechanical loaders, multiple shifting must be resorted to early in the operation, for these machines must be kept in continuous operation in order to justify the heavy capital investment. All types must be depreciated very rapidly for they are comparatively short-lived, also development of new designs soon causes obsolescence.

Conclusion

It can be said that mechanical loading of coal is now definitely out of the experimental stage; all heights and conditions of seam are now being worked successfully, and the basic principle of the various machines has been proved sound. Future developments will be along the lines of simpler and sturdier construction, with a decrease in cost as the production of machines increases.

The great weakness of all types of mechanical loaders is to be found in their complication of design, which leads to inaccessibility of parts and increases the difficulty of assembly. A very large part of the repair work must be done in the working place underground where the illumination is very poor and facilities are not of the best.

Simplicity of design, with ease of dismantling, is the most important factor which is under the control of the designing engineer. Much improvement along these lines has been shown in recent designs, but there is still room for more.

Mechanical loading does not solve all the problems of the industry, and management must give thought to many things having no bearing on mechanization in order to make coal mining profitable.

Radio Developments Applied to Aircraft

By J. H. DELLINGER[1] and H. DIAMOND,[1] WASHINGTON, D. C.

In this paper the authors point out the need for equipment and methods that will reduce the weather hazards of air transportation. Radio offers great possibilities as an aid to flight. Research work carried on by the Bureau of Standards has led to developments through which weather and landing conditions can be communicated to pilots while in flight, and, through course navigation, flying can be done satisfactorily regardless of fog. Many interesting applications of radio to aircraft are described.

WITH the transportation of air mail, express, and passengers constituting its basic source of revenue, the success of air transportation in the United States depends in large measure upon rigorous maintenance of flying schedules by day and night. Means are at hand to cope with every limitation on flight except hazards of weather. Multiple engines and improved controllability assure safety, landing fields are being provided in great numbers, aircraft of adequate strength and stability are available, every comfort and convenience is offered the air traveler. And yet air traffic is still halted when meteorological conditions make the pilot uncertain that he can see landmarks or landing fields.

Limitations on regular commercial flight imposed by weather are, however, being overcome by the aids to air navigation being provided on the civil airways by the Department of Commerce. These aids include the lighting of the airways for night flying, special weather-reporting service, and radio aids.

Possibilities of radio as an aid to flight include: (1) communication, (2) course navigation, and (3) fog landing. Communication is considered by pilots to be most essential. The pilot is interested in receiving information while in the air on weather and landing conditions at possible destinations. A successful system of course navigation, which will permit the pilot to fly his route regardless of fog, is the second element in the conquest of weather hazards. The use of radio to enable a pilot to land in fog is not yet practicable, but promising developments are under way.

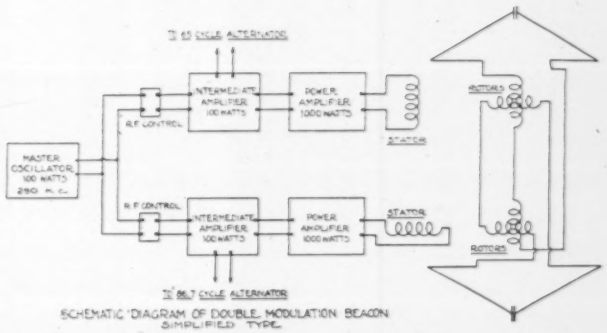
Communication

Communication between aircraft and ground is the simplest and most obvious application of radio as a navigational aid. In times of storm and low visibility the pilot can, by radio communication, be in touch with conditions along his route and learn where a landing can be made most safely. A number of problems at once arise. Shall the communication be by telegraphy or telephony? For the conditions of the U. S. airways the answer is telephony. In some services, military, for instance, radio telegraphy is more suitable, since communication over great distances must be provided for and suitable radio-telephone equipment would be too bulky and heavy.

Another question is whether one-way or two-way telephony is required. Two-way telephony between plane and ground, and between plane and plane, permits individual handling of the problems of each pilot; this is secured at the cost of much heavier equipment and a more cumbersome antenna than for one-way telephony from ground to plane. The radio-telephone service provided by the Government is one-way telephony from ground stations. It may be utilized by all airplanes on the airway by use of only a very simple receiving set weighing a few pounds.

Another problem of a technical-radio character is the choice of frequencies for the services. The beacon and telephone broadcast service are on frequencies between 285 and 350 kilocycles, and the tendency is for the two-way telephone service to be handled on frequencies between 1600 and 6500 kilocycles.

Low-Frequency Telephone Broadcast Service. A definite system of weather reports and radio-telephone communications to aircraft has been inaugurated by the Department of Commerce. Before departing, the pilot is advised as to weather conditions at his destination. After departure, he is advised by radio-telephone broadcasts, at least one an hour, regarding landing and weather conditions along his route, and, if landing at the chosen



SCHEMATIC DIAGRAM OF DOUBLE MODULATION BEACON SIMPLIFIED TYPE.

Fig. 1 Schematic Diagram of Double Modulation Beacon—Simplified Type

destination appears hazardous, he is told of alternate landing fields where a safe landing may be made. Pertinent information, such as ceiling heights, barometric pressure at the level of the landing field, arrangements made for transportation of mail, express, and passengers, and orders from the transport company are given the pilot en route.

With a view to making this information most effective, the Department has begun the use of an automatic telegraph-typewriter system for instantaneous communication between the radio stations at landing fields along the route, weather stations, and operations offices. Timely and accurate information is thus made available to be broadcast to the pilots.

Three radio-telephone weather-broadcast stations have been installed and twelve more are under construction on the transcontinental air route. By June 30 it is hoped to have thirty of these stations in operation on the airways. The frequency band 315 to 350 kilocycles has been allocated to this service.

High-Frequency, Two-Way Telephony. While the above system provides for the broadcasting of such information as is necessary to the safe operation of aircraft, it does not provide the complete facilities for the dispatching of aircraft, essential to the most efficient operation of a transportation service. The air-transport operators are themselves planning to satisfy this need by the establishment of high-frequency radio-telephone two-way communication between aircraft and ground. Sixty-four channels have been reserved for this purpose by the Federal Radio Commission in the 1600–6500 kilocycle band. Radio-telephone transmitting stations on the assigned frequencies will be con-

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[1] Bureau of Standards, Department of Commerce, Washington, D. C.

Presented at the third National Aeronautic Meeting, St. Louis, Mo., May 27 to 30, 1929, of the American Society of Mechanical Engineers. Abridged.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

structed at the principal airports of certain airways, and the airplanes will be equipped with a high-frequency receiving and transmitting set in addition to the low-frequency receiving set required in connection with the Government-operated radio aids. The operations office of each route will maintain a watch on the frequency or frequencies assigned to its aircraft, while the Commerce Department will also maintain a watch on a standard calling frequency. A frequency in the neighborhood of 4000 kilocycles will be used for this purpose. This constitutes a service which admirably supplements the telephone broadcast service provided by the Government on 315–350 kilocycles, and should measurably increase the safety of operations.

COURSE NAVIGATION ON FIXED AIRWAYS

Requirements. The fundamental requirement of a radio system for guiding airplanes traveling the fixed airways is that it shall give the pilot information to enable him to continue along a given airway when no landmarks or sky are visible. If he leaves the course, it should tell him how far off he is, and to which side, should show him the way back to the course, and should inform him when he arrives at his destination. Guidance along the airway means guidance along the route regularly flown, with its emergency fields, lights, and other facilities. Thus the airways guidance system is sharply marked off from direction finding and other systems which are mere homing devices, and with which the pilot can unwittingly be driven off the desired course by side winds. The guidance system must be entirely free from errors of wind drift, since one of its purposes is to prevent collisions, both between airplanes and with the sides of mountain passes, etc. The system must provide service to all airplanes flying the course, and must be adaptable to the complex conditions on the busiest airways.

Besides these requirements, there are a number of additional desiderata which are not strict necessities. The identity of the portion of the airway traversed should be indicated by the radio signals. The service should be continuous rather than intermittent. The pilot should receive the service by a mere glance at an instrument, being free from any necessity of using ear phones, or adjusting anything, or correlating with other instruments, or changing the course of the airplane. The radio frequencies, power, type of emission, and location of transmitting stations should be so chosen as to serve the needs with maximum efficiency and conservation of the limited radio channels. The radio equipment on the airplane should be simple and inexpensive.

All of these requirements and desiderata are fulfilled by the radio-beacon system adopted. This system has been worked out to be applicable under the actual flying conditions encountered on the U. S. airways.

Simplified Visual Radio Beacon. The radio-beacon system employs a special transmitting station on the ground, known as a radio beacon. This is usually located at an airport, just off the landing field. Instead of having a single antenna like an ordinary radio station, it has two loop antennas at right angles with each other. Each of these emits a set of waves which is directive, i.e., it is stronger in one direction than others. When an airplane flies along the line, exactly equidistant from the two beams of radio waves, it receives signals of equal intensity from the two. If the airplane gets off this line, it receives a stronger signal from one than the other.

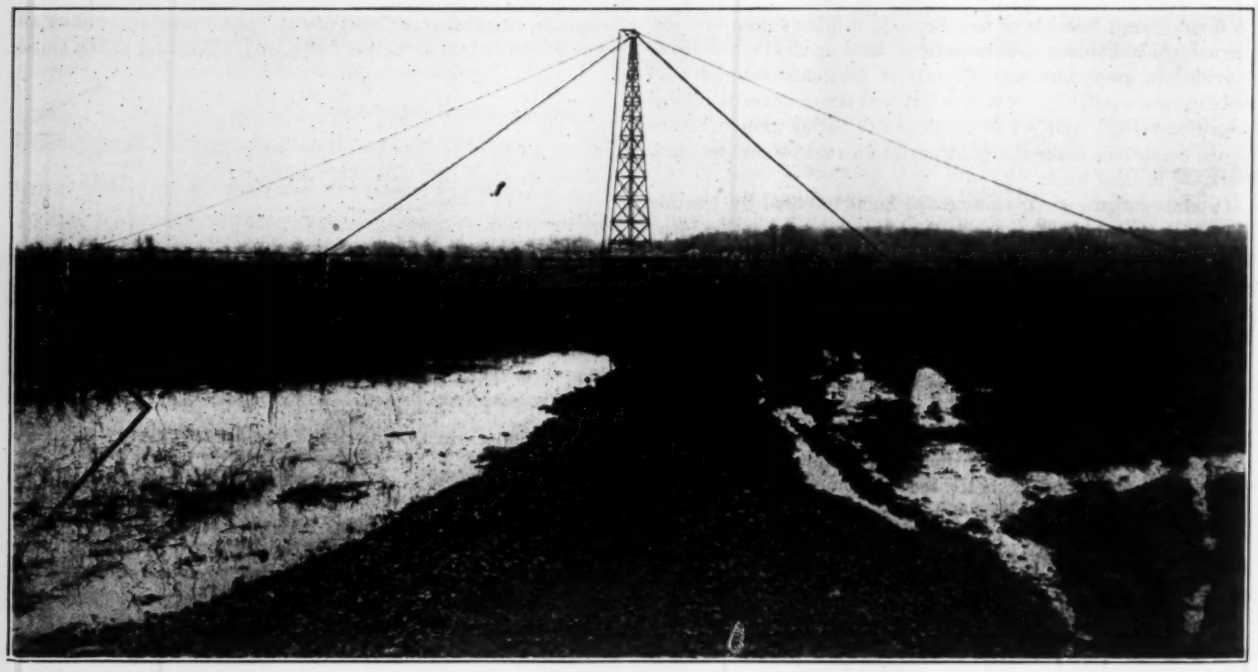


FIG. 2 CROSSED-LOOP ANTENNA SYSTEM USED WITH DIRECTIVE RADIO BEACON. EXPERIMENTAL STATION OF BUREAU OF STANDARDS AT COLLEGE PARK, MD.

The current in the two antennas is of exactly the same radio frequency, but is modulated at a different low frequency in each; i.e., the current in one antenna has a tone of 65 cycles impressed on it, and the current in the other antenna one of 86.7 cycles.

On the airplane, a visual-indicating instrument is used, consisting of two vibrating steel reeds, mechanically tuned to the two beacon modulation frequencies (65 and 86.7 cycles). This instrument is mounted on the instrument board of the airplane and is connected to the output of the receiving set. When the beacon signals are received the two reeds vibrate, and, since they are tuned to the two modulation frequencies used at the beacon, they serve as a device for indicating equality of received

signals from the two antennas. The tips of the reeds are white against a dark background, so that when vibrating they appear as vertical white lines. When the two lines are equal in length the airplane is on its course. A deviation to the left serves to increase the relative deflection of the left reed, and the reverse is true if the airplane deviates to the right. To return to the course, the pilot turns in the direction of the shorter reed deflection.

The radio beacon used in this system is known as the double-modulation beacon. A detailed description was published a year ago.[2] The transmitting apparatus has since been considerably simplified. Fig. 1 is a schematic circuit diagram of the beacon-transmitting station in its simplified form. A 100-watt master oscillator supplies power at 290 kilocycles to two 100-watt intermediate amplifiers which in turn supply power to two 1000-watt power amplifiers. These feed separately into two loop antennas crossed at an angle of 90 deg. to each other. Each intermediate amplifier is modulated to a selected low frequency, 65 cycles being chosen as one modulation frequency and 86.7 cycles as the second. One loop antenna therefore radiates a 290-kilocycle wave modulated to 65 cycles, while the other emits a 290-kilocycle wave modulated to 86.7 cycles. Owing to the directive properties of the loop antennas, the intensity of the waves is a maximum in the directions of the planes of the antennas transmitting them, and zero in the directions perpendicular to these planes. Equality of received signals thus indicates a fixed line or "course" in space, and provides a means for guiding aircraft along that course. For the purpose of orienting the course in any given direction, a four-coil goniometer, consisting of two stator coils crossed at an angle of 90 deg. with each other and two rotor coils also crossed at 90 deg., is employed. The stator coils are connected to the plates of the power amplifiers, while the rotor coils are each connected in series with one antenna. The currents in the antennas due to the driving voltage of each stator coil create a resultant field in a direction such as would be produced by an imaginary or phantom antenna rotatable with the goniometer rotor. Since there are two stator coils, there are two such phantom antennas rotatable as the two rotor coils rotate together, allowing the equisignal zone or "course" in space to be oriented in any direction.

A photograph of the crossed-coil antenna system is shown in Fig. 2. The beacon-transmitting equipment is shown in Fig. 3, and the goniometer used for orienting the course in Fig. 4. A photograph of the vibrating-reed course indicator showing the working parts and also the shockproof holder for mounting on the airplane is given in Fig. 5.

The use of mechanically tuned reeds for reception requires that the modulation frequencies in the beacon transmitter be kept steady within certain definite limits. The degree of frequency constancy required depends upon the design[3] of the vibrating reeds. Improvements incorporated in the reed indicator during the past few months have reduced the requirements to the point where, in many installations, a synchronous motor may be used for driving the two a-c. generators which supply the modulation frequencies. At locations where the variation of the power-supply frequency exceeds 0.2 cycle, it is necessary to employ a motor other than of the synchronous type with provisions for controlling its speed within the desired limit of accuracy. A constant-speed unit having the requisite characteristics has been in satisfactory operation at College Park for the past few months. The speed of this unit is controlled by means of a vacuum-tube-driven tuning fork.

[2] "Development of Radio Aids to Air Navigation," J. H. Dellinger and H. Pratt, Proc. I.R.E., vol. 16, p. 890; July, 1928.

[3] "Design of Tuned-Reed Course Indicators for Aircraft Radio Beacon," F. W. Dunmore, *Bureau of Standards Journal of Research*, Nov., 1928, p. 751. Research Paper No. 28.

Adaptation of Beacon to Four Independent Courses. It is desirable at this point to study the polar pattern of the field radiated by the double-modulation beacon described. One loop antenna radiates a 290-kilocycle wave modulated to 65 cycles, while the other radiates a 290-kilocycle wave modulated to 86.7 cycles. The wave due to each antenna may be resolved into a carrier and two side bands. The carriers in the two loop antennas, being of the same frequency and in time phase, combine into a carrier having its maximum intensity along a plane bisecting the angle between the two antennas. The side bands of the two antennas do not combine since they are of different frequencies. The maximum intensity of each side band is therefore in the plane

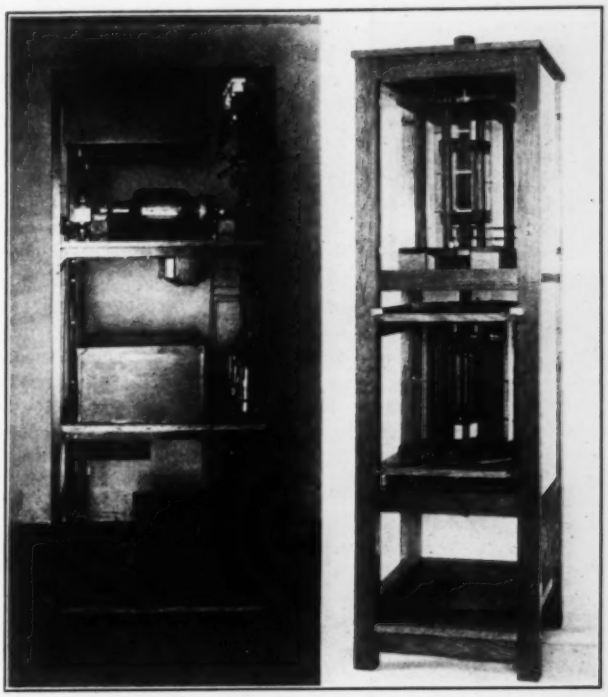


FIG. 3 TRANSMITTING SET FOR DOUBLE-MODULATION BEACON

FIG. 4 GONIOMETER USED IN BEACON STATION TO ORIENT BEACON COURSE IN ANY DESIRED DIRECTION

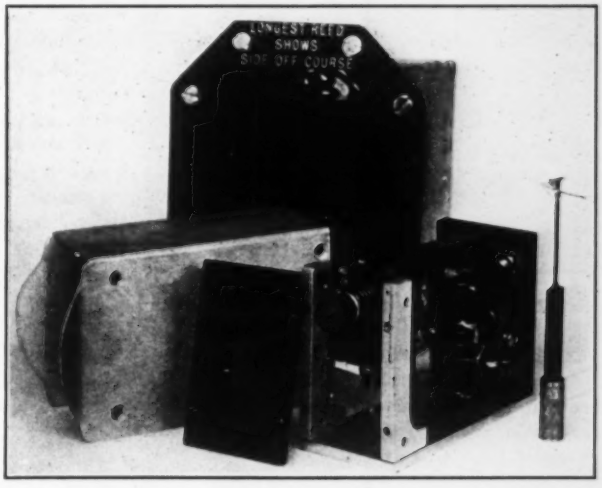


FIG. 5 VISUAL BEACON COURSE INDICATOR

of the antenna radiating it. The space pattern indicating the field intensities of the combined carrier and the two sets of side bands is shown in Fig. 6. Since the reeds operate as a result of the low frequencies in the receiving-set output produced by the beating of the side-band frequencies with the carrier, they respond to a space-pattern characteristic as indicated in Fig. 7. This assumes a square-law detector. It will be noted that but two courses are produced, practically no signal being radiated in the directions at right angles to these courses.

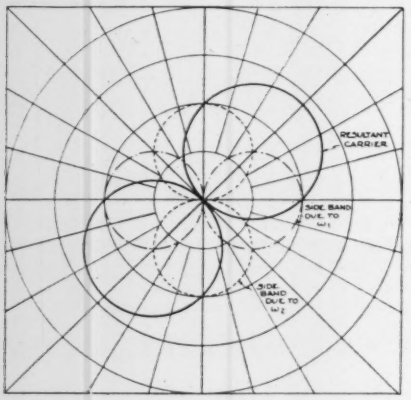


FIG. 6 THEORETICAL SPACE PATTERN RADIATED BY DOUBLE-MODULATION BEACON

In many cases the elimination of the two right-angle courses is desirable. In the application of the beacon to course navigation on the airways, however, airports requiring only two courses 180 deg. from each other are the exception rather than the rule. At those airports where two courses are sufficient, these are usually at an angle other than 180 deg. At many airports more than two radiating courses are necessary, the number varying anywhere from 3 to 8 or even more. The beacon described may be easily modified to permit the use of four courses 90 deg. apart, By a suitable coupling arrangement to the master oscillator, one of the carrier-frequency currents can be advanced in phase 90 deg. ahead of the other. Since the two loop antennas are in 90-deg. space-phase and their carrier currents in 90-deg. time-phase relationship, a revolving field is set up in space, so that the carrier space pattern becomes circular.

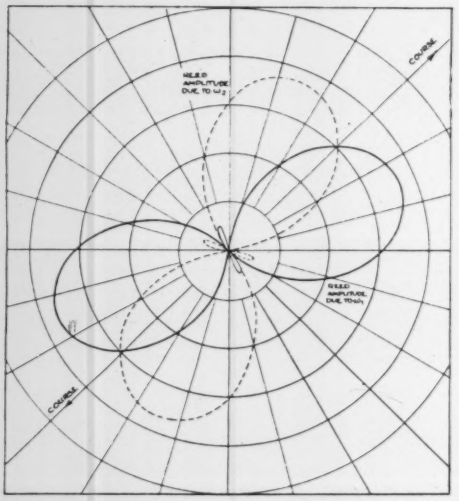


FIG. 7 THEORETICAL RECEIVED POLAR DIAGRAM

A second method is to excite one antenna at a time. The carrier waves radiated by the two loop antennas therefore cannot combine since they are never sent out simultaneously. The space pattern for the carrier wave due to each antenna is then the same as for the corresponding side bands, the maximum power being radiated in the plane of the antenna considered. Again four courses are obtained, these courses being somewhat sharper than above. The switching of the power so that but one antenna is excited at a time may be accomplished electrically at high speed. Owing to mechanical inertia, the reeds maintain their vibration amplitude without interruption or flutter.

The four beacon courses obtained by either of the methods outlined above may be shifted considerably from their 90-deg. relationship in order to make them coincide with the airways radiating from a given airport. Two adjustments at the beacon are possible, the first and simplest being illustrated in Fig. 8. A, B, C, and D are the courses with the beacon normally adjusted. If the figure-8 due to antenna 1 is reduced by reducing the voltage supply from the master oscillator to the amplifier branch feeding antenna 1, courses A', B', C', and D' are obtained. It will be observed that courses A' and C' are still at 180 deg., also courses B' and D', but that the two sets are no longer at 90 deg. with each other. To shift either set of 180-deg. courses (say, B' and D') from their 180-deg. relationship, the method illustrated by Fig. 9 is adopted. A non-directional carrier, of proper phase value, is radiated in addition to the ordinary beacon radiation. A vertical wire extending along the beacon tower and coupled to the beacon set, is used for obtaining this additional radiation. The resultant space pattern is indicated by the heavy lines in Fig. 9. It will be observed that courses B' and D' are no longer at 180 deg.

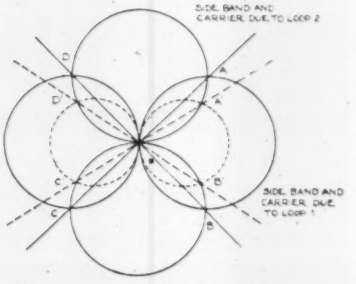


FIG. 8 THEORETICAL SPACE PATTERN FOR SHIFTING THE FOUR BEACON COURSES

Applying these principles, the Airways Division, in cooperation with the Bureau of Standards, has succeeded in fitting the aural beacons at Bellefonte, Pa., and Hadley Field, N. J., to the airways. At Bellefonte, two courses at an angle of 165 deg. are used, while at Hadley the three courses leading to Hartford, Conn., Bellefonte, Pa., and Washington, D. C., are served simultaneously.

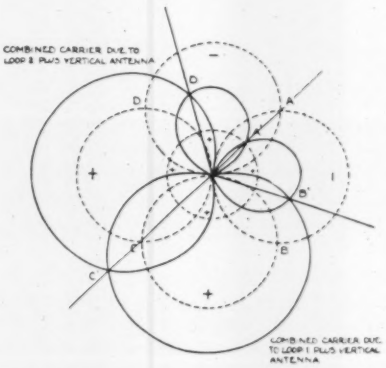


FIG. 9 ALTERNATIVE SPACE PATTERN FOR SHIFTING TWO OF THE FOUR BEACON COURSES

With the visual beacon system, shifting the courses at the beacon is not entirely necessary. A slight change in the receiving equipment aboard the airplane makes it possible for the pilot to choose his own course, so long as he is within about 20 deg. on either side of an equisignal zone. This is accomplished by shunting a suitable resistance across the coil actuating one of the two reeds, thereby reducing the sensitivity of that reed. The course, as determined by equality of reed deflections, is therefore shifted from the true equisignal zone in the direction of the shunted reed. The same effect is thus accomplished as by shifting the courses at the beacon. The shunt resistance may be made variable and calibrated in terms of degrees off the true equisignal zone, to give additional flexibility to the system.

Multidirectional Beacon (12 Courses). To render the beacon system still more flexible and thus make it suitable for use at

cities located at the junction of a large number of airways, a new beacon has been developed capable of serving twelve courses simultaneously. The increase in apparatus over the beacon described above is not great. The same cross-coil antenna system and the same circuit arrangements are employed except that three amplifier branches, modulated to three different frequencies, are necessary. The modulation frequencies used are 65, 86.7 and 108.3 cycles, respectively. A special goniometer is also required. The rotor system of this goniometer is the same as before; three stator coils are, however, required, one being connected to each power-amplifier tube. The stator coils are disposed at 120 deg. to each other.

Since the stator coils are not at right angles to each other, it is essential that but one stator be excited at any given time in order that coupling between stators be avoided. A high-speed electrical switching arrangement has been provided in the grid circuits of the intermediate amplifier tubes for accomplishing this purpose.

Assume that a pilot is equipped with three reed boxes, the first tuned to 65 and 86.7 cycles, the second to 86.7 and 108.3 cycles, and the third to 108.3 and 65 cycles. He will find four courses with each. Two of each set of four courses have an equisignal zone of 1 to 1.5 deg., while the equisignal zone for the other two courses is from 3 to 4 deg. wide. There are thus twelve useful courses provided, any two adjacent courses being separated by 30 deg.

Some routes radiating from an airport may, however, be at angles differing from 30 deg. This difficulty is not insurmountable, since the angles between adjacent courses may be so adjusted by changes at the transmitter as to fit the courses to those airways.

A 12-course beacon of the type described has been installed at College Park, Md., and is giving satisfactory results.

Marker Beacons. The directive radio beacon will successfully guide a pilot along a given course, but does not directly indicate his exact location along that course. Where it is desirable that this indication be given, for example, at the intersection of two beacon courses or at a dangerous portion of the airway, it can be obtained by the installation of a small non-directive marker beacon, which is of very low power (a few watts) and emits a characteristic coded signal. This signal operates a 120-cycle reed indicator suitably located on the airplane instrument board, and is received for two or three minutes as the airplane passes over the marker. The pilot can thus locate his exact position on the airway. The coded signal of the marker beacon can have the same characteristics as the light beacon if there is one there.

Airplane Receiving Sets. The beacon system can be used with any receiving set which operates at the frequencies employed, by merely replacing the telephone receivers by the simple reed indicator unit. There are, however, a number of special conditions involved in receiving on an airplane, and the Bureau has developed special receiving sets[4] in order to use the beacon system under the most advantageous conditions.

The receiving set designed weighs less than 15 lb., the auxiliary batteries weighing an additional 10 lb. The receiving set operates in the frequency range from 285 to 350 kilocycles and is used to receive either the beacon signals or radio-telephone weather messages at will. It is highly selective as well as sensitive, and is provided with interstage shielding as well as shielding against direct extraneous interference. The audio-frequency amplifier is specially designed to be efficient at the low modulation frequencies used in the beacon. The selectivity of the set is supplemented by the selectivity of the vibrating reeds, which helps greatly in reducing interference. Nevertheless it is important that a good degree of set selectivity be provided in order to make the most efficient use of the frequency channels provided for this service and also to make the receiving set suitable for the reception of weather-telephone messages. The set has remote-control arrangements for tuning and volume, so that it may be mounted in any location on the airplane.

One model already available commercially has proved very satisfactory; this model, with all auxiliary batteries necessary, weighs approximately 20 lb.

Airplane Antenna. The development of receiving sets having the necessary sensitivity, made possible the use of an antenna system on the airplane consisting of a metal pole extending vertically from the fuselage, the total length of this pole being but 8 ft. A great advantage of the vertical-pole antenna is that it is entirely non-directive. As a consequence, spurious direction variations in the beacon course, which have previously been observed at night, are practically eliminated. In addition, since this type of antenna is affected only by the vertical components of the electric field radiated by the beacon, a region of zero signal strength is met with directly above the beacon tower (where no vertical field exists). This serves quite effectively as a field localizer, locating the landing field within 1000 to 2000 ft. The Bureau's experimental airplane with its vertical-pole antenna is shown in Fig. 10.

FIG. 10 AIRPLANE EQUIPPED WITH VERTICAL-POLE ANTENNA

Ignition Shielding. The use of a sensitive receiving set together with the short vertical antenna, located near the airplane-engine ignition system, makes necessary a considerably more rigorous shielding of the ignition system than is ordinarily required to prevent ignition interference. Merely shielding the high- and low-tension wires is not sufficient. The spark plugs and the magneto distributor blocks must also be shielded.

One particular shielding arrangement suitable for installation on a Wright J-5 engine, it is believed, with certain improvements in the mechanical design will be quite satisfactory from an operating viewpoint. Full provisions are made for mechanical sturdiness, freedom from disturbance of the ignition system, and waterproofing of all parts.

COURSE NAVIGATION ON INDEPENDENT ROUTES

As may be apparent in the description of the multidirectional beacon, an airplane receives beacon indications at all points and not merely on the established airways. It thus gives guidance service to any one flying to or from the beacon, even though he fly an independent route. There are, however, a variety of other possible radio-navigational systems for the independent flier.

Direction Finder on Ground. This is the system used on the airways of Europe. Radio direction-finding stations are maintained by the governments at various airports, and each airplane carries both a transmitting and a receiving set. Upon request by radio from an airplane, two or more of the direction-finding

[4] "Receiving Sets for Aircraft Beacon and Telephony," H. Pratt and H. Diamond, *Bureau of Standards Journal of Research*, Oct., 1928, p. 543. Research Paper No. 19.

stations determine the direction of travel of radio waves from the airplane; combining their determinations, they calculate the airplane's position and send this information by radio to the airplane. This system has had a little application in the United States during the past year.

Direction Finder on Airplane. A second means of radio navigation for the independent flier is the use of a radio direction finder on the airplane. By steering a course in the indicated direction of a radio station on the ground, the airplane can be certain of reaching that point, the accuracy of the indicated direction increasing as the objective is approached. Direction finders are used extensively as navigational instruments on marine vessels and on lighter-than-air craft. On airplanes it is considerably more difficult to protect them from error and disturbances caused by the engine ignition and other sources. They have been used successfully to some extent, and their use will doubtless increase; they do, however, require expert handling. This method of navigation has the inherent limitation that it does not prevent wind drift from shifting the airplane off its course; the method does, eventually, bring the airplane to its destination, although by a circuitous route if there is a side wind.

Rotating Directive Beacon. A third method of furnishing navigational aid to the independent flier is the rotating radio beacon. This is a radio transmitting station, located at an airport, which has a directive antenna rotating at a constant speed of one revolution per minute. A figure-8 pattern is thus rotated in space. A special signal indicates when the figure-8 minimum passes through north and also when it passes through east. A pilot listening for the beacon signal with his receiving set can start a stop watch when the north signal is received and stop it when the figure-8 minimum reaches him. The number of seconds multiplied by 6 gives him his true direction in degrees from north. The stop watch may be calibrated directly in degrees, so that the position of the second hand when the minimum signal is received gives the bearing directly. This system thus serves any course within its range. It has, however, the disadvantages of slowness of operation and also of being difficult to use during conditions of severe atmospheric disturbances or interference from outside sources, besides the common disadvantage of all these methods, namely, the use of headphones.

Fog Landing

By the use of the radio aids being installed on the U. S. airways it will become entirely feasible to maintain a course between any two points along a given airway and to arrive within a few thousand feet of the desired destination regardless of weathe conditions. The matter of effecting a safe landing during fog and extremely low visibility is not yet, however, an assured accomplishment.

Recent tests indicate that fog-penetrating lights are not yet available. The dissipation of fog by mechanical means has been the subject of much laboratory experimentation, the general result being that it is not economically possible on a useful scale.

The most feasible method of attack at the present time appears to be in the application of radio. When attacked from this angle, the problem resolves itself into two separate problems: namely, field localizing, and the development of a suitable altimeter.

Field Localizers. Practically all previous experimentation in this field has been in the use of "leader cables." The principal installations are those of the British Government at Farnborough and of the French Government at Chartres. The British installation consists of an oval loop of cable about 5 × 2 miles, buried 2 ft. in the ground. One of the straight sides of this oval loop passes through the airdrome. Near this straight side and surrounding the portion of the airdrome free from obstructions is a second smaller oval loop. A pilot circles around the major loop, coming lower and lower. Once each revolution he receives a signal from the smaller loop, indicating that he is directly over the airdrome. When he is at a sufficiently low altitude and over the airdrome a safe landing may be effected. An obvious disadvantage of this method of field localizing is its great cost.

The success obtained with the directive radio beacon in its application to point-to-point flying, suggests its possibilities as a field localizer. With the main beacon used for guiding an airplane to a given landing field, a low-power beacon with small loop antennas may be employed for marking out the major or most desirable axis or runway of the landing field. This can be done quite as effectively as with leader cables.

Altimeters. A desirable adjunct to any method of field localizing is the development of an instrument to show accurately the height of an airplane above the ground, allowing an error of but a few feet. The barometric instruments now in general use are not adequate for the purpose, as the best ones have an accuracy no greater than about 5.0 ft., and their use requires a knowledge of the barometric pressure at the ground.

Experiments are being undertaken looking toward the development of suitable sensitive altimeters of types which measure height above ground. One is the development of a sonic altimeter. This is an instrument on the airplane which measures the time taken by a sound wave emitted from the airplane to reach the ground and return to the airplane by reflection. Knowing the average velocity of sound, the height of the airplane above the ground is determined.

Another device is the capacity altimeter, which measures the distance from the ground by detecting the change in the electrical capacity between two plates on the airplane as the airplane approaches the ground. A limit presents a possibilities of this type of instrument is set by the fact that the change in capacity becomes infinitesimal at altitudes exceeding 100 ft.

A third method is by the use of direct reflection with radio waves. The most recent work on this type of altimeter is reported by Dr. E. F. W. Alexanderson. With the development of an accurate altimeter and field localizing system the last obstacle in the battle with fog will be overcome.

Recent Demonstrations

1 On a day of low visibility, a pilot, unfamiliar with the route, took the air in Philadelphia for Washington with no maps or instructions as to landmarks; he was told to proceed to Washington (a distance of 120 miles) and land at College Park Field solely in accordance with the guidance given by the beacon indicator on his instrument board. He not only flew in a straight line to Washington, but when over College Park Field, the location of which he did not know, the sudden drop in the reed deflections told him he was at his journey's end, whereupon he landed.

2 The remarkable selectivity of the reed indicator has been demonstrated in several test flights from College Park, Md., to Hadley Field, N. J., with the double-modulation-type College Park beacon and the aural-type Hadley beacon, both operating on the same radio frequency and with approximately the same power. With the particular type of receiving set employed, the interference of the Hadley Field beacon does not interfere with the operation of the reeds until the airplane is approximately 140 miles from College Park and only 50 miles from Hadley. This is an interference-to-signal ratio of about 8 to 1.

3 An additional test also demonstrating the degree of freedom from interference of the reed indicator was made on an unshielded airplane at Hadley Field, using a different type of receiving set. The College Park beacon signals were used, the reeds functioning perfectly at all engine speeds, even though the ignition interference present was sufficient to render a signal from a nearby radiotelephone set unintelligible.

Modern Practice in the Quarrying and Milling of Marble

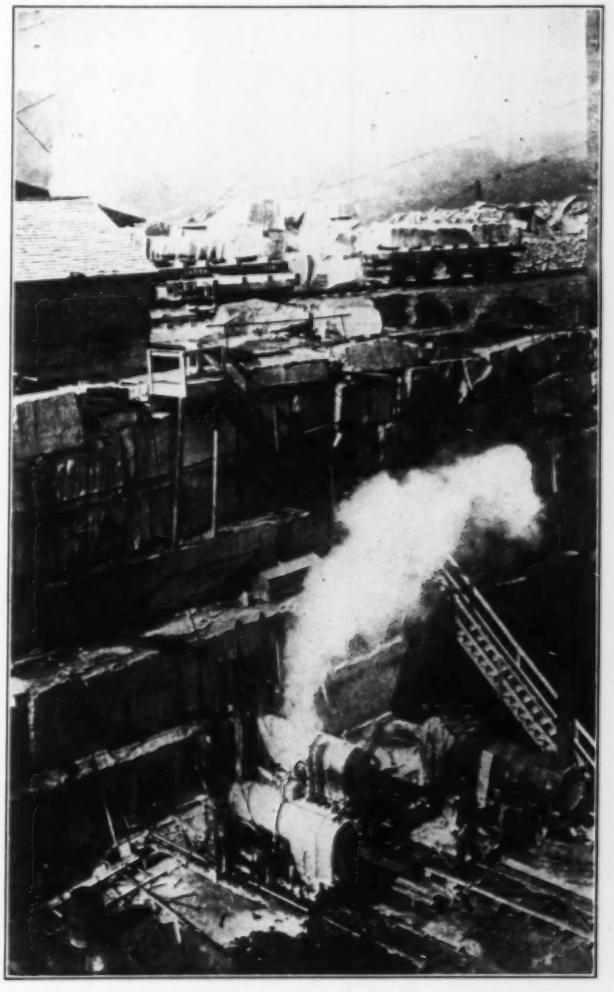
Quarrying Operations—Sawing Marble Blocks Into Slabs and Grinding, Rubbing, and Polishing Them—Production of Moldings, Columns, and Fluted and Curved Work in Lathe- and Planer-Type Carborundum-Wheel Grinding Machines

By J. P. McCLUSKEY,[1] KNOXVILLE, TENN.

THE desire of marble quarrymen of all times has been to loosen from the beds blocks of marble of varying sizes and the greatest possible degree of soundness. The first operation employed to accomplish this as far back as there is any evidence, and at the present time, has been to cut a channel around the block or mass desired, after which wedges are driven in an unsoundness to raise the block, or holes are drilled at the floor line to make a place for wedges. The earliest efforts to make these cuts were those where the channel was beaten out around the stone desired, using hammers made of a stone much harder than that in which the channel was being cut. As late as 1863 channels 30 ft. long by 8 ft. deep were cut by hand in the quarry now operated by the Alabama Marble Company. These cuts were 2½ ft. wide at the surface, gradually narrowing toward the 8-ft. depth, until at the bottom they were only 6 in. wide, or just wide enough for the laborer to place one foot in advance of the other. This was accomplished mostly with sla[illegible] steel pick[illegible] although some free labor was used at a wage of 25 c[illegible] At a point 8 ft. down the face of the ledge, to correspond[illegible] the depth of the channel cut, a row of holes were drilled and filled with water; then wooden plugs were driven in which absorbed the water, swelled, and lifted the mass of marble. Approximately forty years after this operation some of the resulting loosened marble was taken out by the author, who found evidence that the entire procedure was as indicated above, even down to the wooden wedges.

Channeling—Drilling

In 1863 the Wardell steam channeler was brought out in Vermont. This machine lifted a gang of bits by means of a cam and allowed them to drop upon the marble of their own weight. This being done rapidly while traveling back and forth on a track, cut a channel 2 to 3 in. wide and of any depth up to 10 or 12 ft., possibly more. This machine at first was provided with one cutting head and one gang of bits, and had a horizontal boiler on the carriage. A later development had a cutting head on both sides of the track which could be operated at the same time, cutting two channels at once. Later the boiler was taken off and an electric motor used instead. This machine, while cumbersome and because of its rigid cutting heads capable of making only vertical cuts, had the advantage of being very economical in operation. Later the Sullivan and Ingersoll channelers came on the market having swinging heads that could be tilted back to any angle, even to the horizontal. There have been channelers on bars, hill-climbing channelers, double-head channelers having a head on each end of the carriage, and the duplex, having two heads hung on the same frame and operated by valve motion between the two cutting heads. The latest development in channelers is the electric-air machine which only requires a 15-hp. motor as against the 40-hp. boiler needed to operate a steam channeler. This machine accomplishes the same results that Wardell's machine did, but its more efficient application of power results in a more rapid piston stroke. The motor on the electric-air



Channelers Operating in a Vermont Quarry

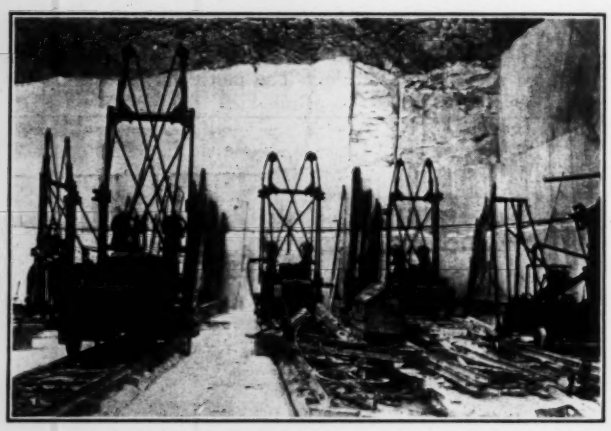
channeler drives an air "pulsator" which has two air cylinders with a crankshaft between the two. Each of these cylinders is connected with the chopping cylinder by two 3-in. hose approximately 7 ft. long, one leading from the top cylinder of the pulsator to the top of the chopping cylinder, and the other from the lower cylinder of the pulsator to the lower end of the

[1] Superintendent, Gray Knox Marble Company.

Presented at the Knoxville Meeting of The American Society of Mechanical Engineers, Knoxville, Tenn., March 21–23, 1929.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

chopping cylinder. The result of the operation of the crankshaft in the pulsator is that one stroke of the pulsator piston lifts the gang of bits attached to the piston of the chopping engine, while the reverse stroke of the pulsator piston drives the gang of bits down on the marble. There is no exhaust as the air is simply driven back and forth between the pulsator and the chopping cylinder. The chief advantages of this machine are its low power consumption and the fact that it is not necessary to carry pipes over and about the quarry, the only connection necessary being that of the electric cable. It is capable of cutting vertical, inclined, or horizontal cuts, and, as it has a much smaller number of parts, there are fewer repairs which, with no pipe connections to look after, results in a higher time efficiency and consequently more channel cut per day.



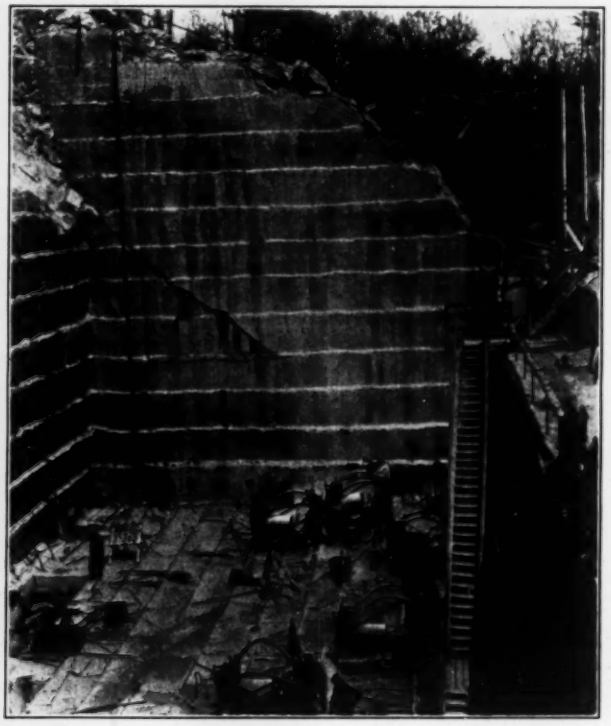
DOUBLE-HEAD CHANNELERS OPERATED WITH MOTOR IN A VERMONT QUARRY—ONE MODERN STEAM CHANNELER AT RIGHT

TYPICAL VIEW IN TENNESSEE QUARRY. LINES OF HOLES IN WALL ARE IN PREPARATION FOR FUTURE DEVELOPMENT

We are all more or less familiar with the old hand method of drilling holes in marble. Only a few years ago in Tennessee one man's task for the day was 25 lineal feet of $1^1/_2$-in. holes 12 to 24 in. deep, the wages being 90 cents a day. Frequently one or more men had to work overtime to accomplish this task. For deeper holes three men were used, one to "shake" or turn the steel and two to "strike" alternately. Forty to fifty feet was a day's work for these drillers.

The earlier efforts of the Sullivan concern to improve on hand methods resulted in a gang of diamond core drills. These were quite successful and might have been extensively adopted, but the rising price of diamonds, coupled with the development of machine drills, put them out of use.

England and Germany produced the first machine drills in 1844 and 1853, respectively. Fowle of Boston invented the first drill used in the United States. Later improvements by Burleigh bring us to his design used in 1866 in the Hoosac tunnel in Massachusetts. After Burleigh's came the designs of Ingersoll, Sergeant, Githens, and Sullivan, bringing us up to 1897 when the hammer-type drill was introduced, using hollow steel bits, through which water or air was forced, thus keeping the hole clean. The earlier piston drills were heavy and inefficient because of the weight of the drill bits attached to the piston, slow valve motion, and indirect application of power. The piston drills weighing 300 to 400 lb. cut as high as 150 lineal feet of drill holes per day, using two men and 125 to 150 cu. ft. of air, whereas the hammer-type drill, weighing 35 to 40 lb., using one man and 100 cu. ft. of air, cuts on an average 200



QUARRY AT ROXBURY, VT., FROM WHICH IS OBTAINED VERY BEAUTIFUL VERDE ANTIQUE MARBLE

lineal feet of drill holes, the highest record known for hand-feed hammer-type drills being 410 lineal feet in 10 hours.

The most modern drill is the hammer-type, with an air-feed appliance to replace the crank-and-screw feed. We are now drilling as high as 1000 lineal feet of holes per 10-hour day under test conditions.

Drilling and channeling have been gone into rather extensively as they are the two basic operations in quarrying, other operations and machinery being either accessory or secondary in importance.

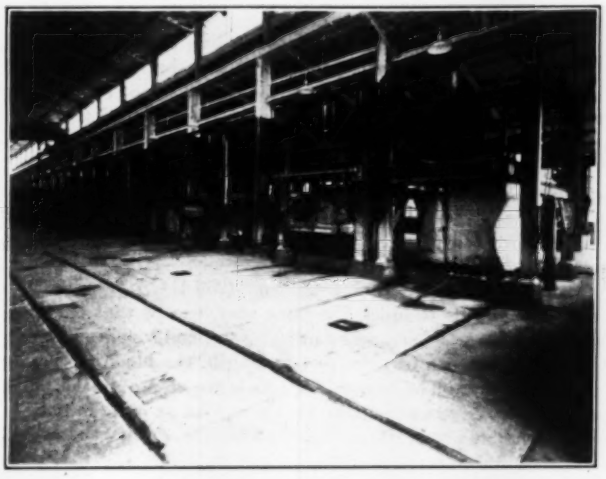
DERRICKS

Quarry operators are, in numerous instances, getting away from steam equipment as rapidly as possible. In most cases the steam plants are old and inefficient, and electric power is be-

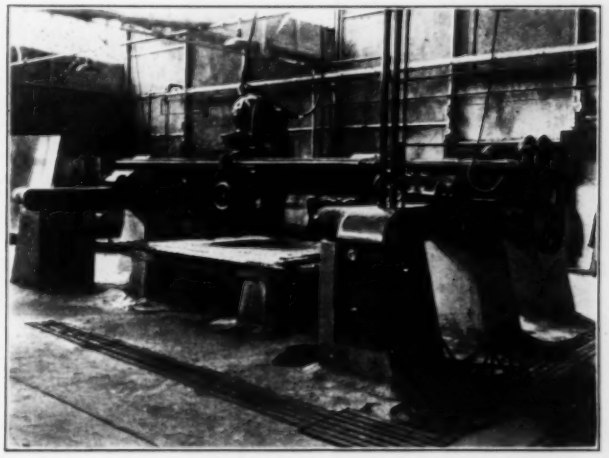
coming more available to the isolated locations in which marble quarries are often situated. Channelers, hoists for derricks, and air compressors are the largest users of power around a quarry, and in each case electric equipment for these purposes is better from any angle. The greatest amount of power is required for driving air compressors as each drill requires about 130 cu. ft. of air per minute at 100 lb. pressure, and since several of our large quarries have as many as 25 drills operating at a single location, it is evident that compressors of 2000 cu. ft. capacity and over are needed. A compressor of this size is driven by a 325-hp. motor.

Several quarries in Tennessee are operating as many as eight steel derricks in one quarry. These derricks vary in size from those having masts 100 ft. high with booms 90 ft. in length to those 115 ft. high with 100-ft. booms. Lifting capacities vary from 35 tons to 50 tons. If electrically operated, each derrick requires a 40- to a 60-hp. motor, depending upon the number of sheaves in the hoisting blocks; 40-hp. derricks are usual in Tennessee.

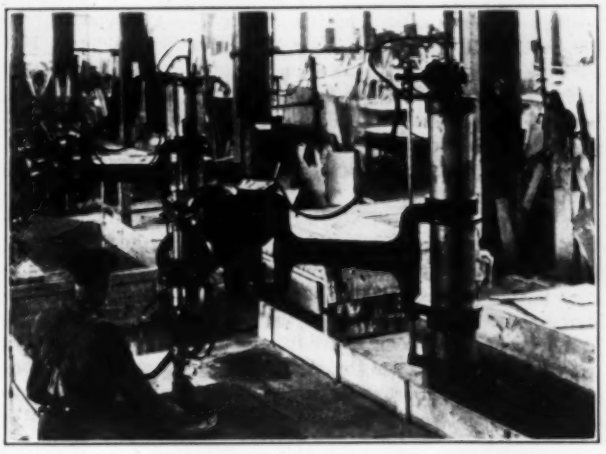
Previous to the use of fabricated-steel derricks, large timbers were used. Some of these timbers were obtained locally, but sticks over 60 ft. in length were difficult to find, therefore Oregon fir was used to supplement the local timber. The masts brought from Oregon were as much as 110 ft. in length, and, with heavy castings at base and cap and ten or twelve $1^1/_4$-in. steel cables for guys, could lift 50 tons if necessary.



BATTERY OF GANG SAWS IN A KNOXVILLE, TENN., MILL



MARBLE-COPING MACHINE FOR SQUARING SLABS OR CUTTING STRIPS OR TILE WITH THIN CARBORUNDUM WHEELS



BUFFING OR POLISHING SLABS OF MARBLE FOR WAINSCOTING

ONE COLUMN READY TO BE PUT IN LATHE, ONE IN LATHE, AND ONE FINISHED. CARBORUNDUM WHEELS USED FOR LATHE WORK

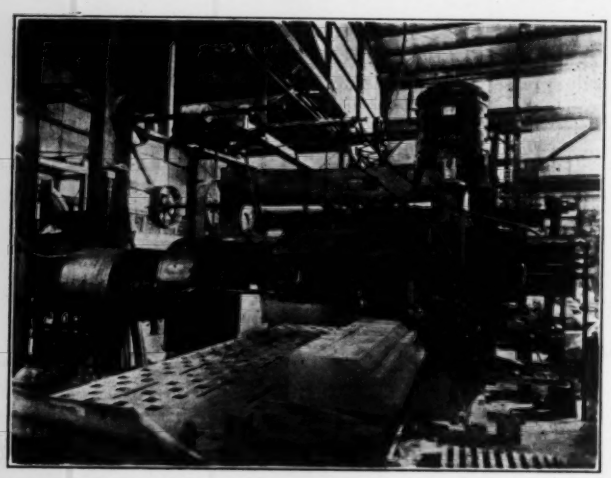
DISPOSAL OF MARBLE WASTE

Disposal of marble waste is one of the serious problems of quarry operators. A small percentage is burned into lime, and a still smaller percentage is sold for rip-rap, but the amount received therefor is not sufficient to compensate the operator for the expense of the tracks, dinkeys, cars and land upon which to dump the waste. It is doubtful whether 20 per cent of the operators' product is finally placed in buildings, the other 80 per cent being lost as irregular-shaped or unsound marble from channel cuts, drill lines, and from squaring up blocks. These items represent losses at the quarry which roughly would account for 45 per cent, the remaining 35 per cent resulting from losses in manufacturing. These figures are taken from the experience of successful marble companies, and are believed to be fair estimates.

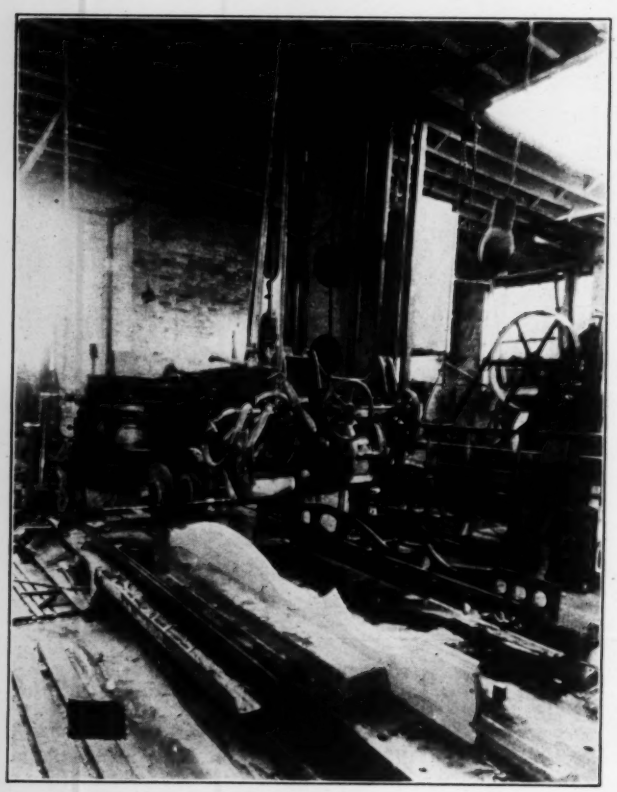
SAWING BLOCKS INTO SLABS

After the operator has produced his marble it is delivered

to the mill for manufacturing. The first milling operation is that of sawing the blocks into slabs. The blocks are of varying sizes, but for the sake of discussion let us assume one 7 ft. long, 5 ft. wide, and 3 ft. thick, an average size. This block is loaded on a gang car at the mill and pushed under the gang of blades. These blades are flat straps of soft steel usually $3^1/_2$ in. $\times$ $^1/_8$ in. and from 10 to 16 ft. in length, depending on the length of



MACHINING A HEAVY CORNICE



FORMING MARBLE TRIM. NOTE PATTERN AT RIGHT, GOVERNING ACTION OF WHEEL

the gang frame. The gang frame is 12 to 14 ft. high, 7 ft. wide and 10 to 16 ft. in length. This 7-ft. width will take 50, 60, or 70 saw blades, or ten blades for each foot of width if the block is to be sawed into $^7/_8$-in. slabs, or fewer if thicker slabs are desired. At each corner of the gang frame is a feed screw that automatically feeds the blades down on the block of marble, usually at a rate of about $^3/_4$ in. per hour in Tennessee marble and varying according to the number of blades in the gang, the quality of sand used, and the kind of marble sawed. The gang is driven by a pitman, steel or wood, about 14 ft. in length, connected to one crosshead of the gang and the driving crankshaft of the hurst frame. The crankshaft is driven by a belt from a lineshaft overhead, two to four gangs being operated from one lineshaft and one motor. In some cases as many as ten or more gangs are operated from one lineshaft, but it is not considered to be the best practice. As the gang of blades is driven back and forth across the block of marble, a continuous stream of sand and water is distributed over the top of the block, and the blades, having a 16- or an 18-in. stroke, are lifted slightly at the end of each stroke, touching the marble only at the middle of the stroke. This slight lift allows a fresh supply of sand to be washed under the blades. It is very detrimental to have the feed speeded up to such an extent that this lifting of the blades is prevented, for, sawing being slowed down, and assuming that the feed is not promptly adjusted, the blade will turn sideways in the block of marble, making waves in the slabs, which either ruin them or require an undue amount of rubbing to remove the waves.

It is interesting to note that Pliny (250 B.C.) describes the sawing of marble in much the same way, except that one sawblade was used, the arrangement being to bend a pole as though to make a bow ten or more feet in length, the blade answering as a bowstring. The heavy bow was suspended over the block of marble to be sawed and, stationing a man at each end of the bow, the blade was drawn back and forth across the block, sand and water being fed to the saw cut from the top. We now use more sawblades and mechanical power.

COPING THE SLABS

When the slabs come from the gangs they are coped to approximately the size required for placing in the building. If a mechanical coper is used the edges are true and do not require further attention. If coped by hand a certain amount of stock, from $^1/_4$ in. to $^1/_2$ in. has to be left for rubbing down to exact size, as the hand operation consists in "laying out" the desired size with a square and a straight edge, tracing the lines with a hand chisel or pneumatic tool, and then breaking along the traced lines. The rough edge left from the hand coping makes necessary an undue number of operations later and is not the most economical practice except in marbles having various color patterns which require matched panels or tedious selection, by the coper, to arrive at the most desirable color effect. In marbles of even color distribution a carborundum coper is a great improvement over the hand method; a gang coper, one having several carborundum wheels, will cope about twice as much as a hand coper. A still greater saving results from the fact that the machine-coped material requires no further operations as compared with material coped by hand which has half an inch on all edges to be taken off in later operations. Some marbles that are exceedingly unsound but still in continuous demand owing to their great beauty, must of necessity be coped by machine as the innumerable cracks will open up under the strokes of the coper's hand hammer or the vibrations of an air hammer.

RUBBING

The next operation in the mill is rubbing. This is accomplished with a disk of iron 4 in. thick by 12 to 14 ft. in diameter. This disk is mounted horizontally on a spider which is driven by a vertical shaft in the center, which in turn is operated by

gears and countershaft overhead, the disk, spider, and shaft being supported underneath by a ball bearing in the center. The slabs are laid flat on this revolving disk, and sand and water are fed to the surface of the bed from the center; centrifugal force keeps the sand distributed evenly over the beds, the worn-out sand escaping over the edge. The large gears at the top of the vertical shaft are set with wooden teeth, which reduces the vibration to a minimum.

Before the slabs are "rubbed" as just described, they are referred to in the trade as "sawed slabs," the next operation reduces them to "coped stock." After the rubbing process they have a "sand rubbed" finish. From the rubbing beds the marble is carried to the gritting machines. A gritting machine is a revolving head 12 to 16 in. in diameter in which gritting blocks of varying degrees of fineness are set in non-abrasive cement. It is necessary to use more than one gritting head on slabs or pieces that are to have a smooth "hone" finish preparatory to buffing or polishing: first a relatively coarse grit, then a finer one, the surface of the marble being kept wet during the process.

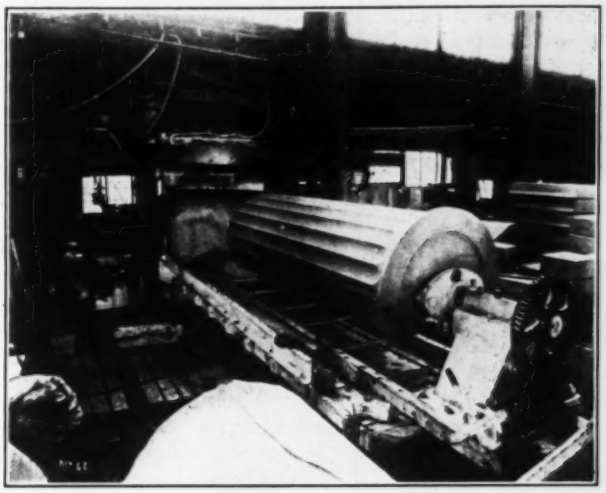
Buffing and Polishing Honed Slabs

After gritting, the slab is placed under the buffer, which is the same as a gritting machine except that a felt head is used instead of a gritting head. This felt disk is 20 in. in diameter and 2 in. thick. "Putty powder" (chromium oxide) or tin oxide, together with oxalic acid, is distributed under the revolving buffer head for polishing. These powders are used with water as caution must be exercised to keep the slab from "burning" under the action of the buffer, which delays or possibly prevents polishing. The buffing operation only applies to plane surfaces, most of the present discussion centering around slabs from $^{7}/_{8}$ in. to 2 in. in thickness and intended for wainscoting, toilet partitions, and similar work. Moldings, circular work, or any carvings that have to be polished must be polished by hand. The same general process is followed in hand polishing as in machine: that is, when the hand polisher is given a carving or a molding from the carborundum machine to polish, he first uses an abrasive block that fits his hand comfortably to "grit," then a finer piece of abrasive to "hone," and finally a piece of felt or cloth pad to "shine" or polish. The same polishing powders and oxalic acid are used in both processes.

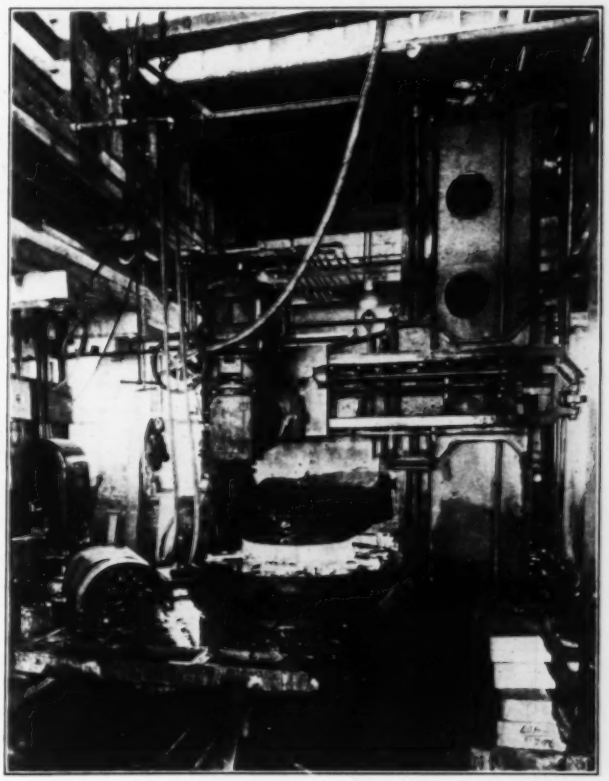
Machining Moldings, Columns, Fluted Work, Etc.

Thin stock or "slabs" comprise the larger part of the output of an interior-marble shop. However, there is still a large amount of marble used for interiors in addition to wainscoting, such as stair work, balusters, straight and curved moldings, fluted columns and column caps, bank screens, check desks, etc. Various carborundum machines are used for most of this work, but while planers and lathes are still a part of the equipment of most marble shops, carborundum machines have practically replaced the old-style machines using steel cutting tools.

A carborundum machine, speaking generally, is a machine to do planer and lathe work, and is of somewhat similar appearance but uses rapidly revolving carborundum wheels to do the cutting, the wheels being drenched with water during their contact with the marble. "Coping" machines are similar in general appearance to a planer, having the slabs fed to the wheels on a platen. As a matter of fact, old-style planers and lathes are frequently changed into carborundum machines by taking off the old heads or tool holders and substituting motor-driven carborundum wheels to do the cutting. There are modern machines for cutting twisted curves such as "ramp twist" stairway hand rails, newel posts, and similar work that would be impossible for an old-style machine to perform. To give the desired mold, flute, or pattern on the surface of the marble being worked the wheel must be prepared in a turning lathe by means of ordinary emery-wheel "dressers," by which a negative of the mold desired is made in the face of the wheel. The wheel is then placed on the arbor of the carborundum planer or lathe, after which the marble is fed against it. Most decorative work has to be cut or carved by hand, pneumatic tools being used very largely, and while machines have been perfected to accomplish practically any of the operations that are typical or often repeated, there are, and will continue to be, sufficient



Column Drum Being Fluted



Carborundum Machine Cutting Column Caps in "Black and Gold" Marble

original designs requiring the employment of carvers and cutters in all shops doing any considerable amount of work.

Circular saws with diamond teeth are a part of the equipment of most marble mills. These vary from 20 in. to 72 in. in diameter. Some styles have the block of marble fed to the saw on a moving bed, while others feed the blade to the stationary block of marble. The first cost of a diamond saw is high as it takes a very high and heavy frame to operate a 72-in. saw at a high rate of speed. The diamond teeth are also expensive, but maintenance charges are low, especially when the rapid cutting of this machine is considered. A 72-in. saw will take a block of marble 30 in. high, and will cut its way through such a block at the rate of approximately six feet in seven hours. On a block this high the saw is run at its slowest speed, while on small work the speed is increased, with a corresponding increase in cutting. Since a gang saw will not cut more than two inches per hour even with one or two blades, the advantage of a diamond saw over the gang saw for a single cut is obvious.

This article has dealt with the larger operations employed in a modern marble quarry and mill devoted to the interior-marble business, and has centered largely on practice in and around the Tennessee marble field. While the same appliances are in use in practically all the marble plants in the United States, the results obtained vary somewhat in different marbles.

Limit-Wear-Load Tests[1]

Progress Report No. 14 of the A.S.M.E. Special Research Committee on Strength of Gear Teeth[2]

THE original tests on the Lewis gear-testing machine were made by determining the load and speed relationship required to just break the electrical circuit through the gear-tooth faces when operated under load. An analysis of these data resulted in the formulation of a series of equations to determine the amount of separation caused by the acceleration due to effective errors in the gear-tooth profiles and the intensity of the impact load resulting from this separation. This analysis is given in Progress Reports Nos. 4 to 10, inclusive, and the calculated amounts of separation were within the range which might be expected on the testing machine.

Progress Report No. 11 gives an analysis of the limit wear loads and the results of tests where signs of distress appeared on the tooth surfaces. This present report covers a series of tests made at different pitch-line velocities with loads sufficient to cause signs of distress to appear. In these tests the failure of the surface of the materials was used as a measure of the actual impact loads, and this enables the tentative equations developed in the earlier reports to be tested for their general accuracy independently of the original tests. If these equations give a reasonably close approximation to the truth, then the calculated impact loads and resulting maximum specific compressive stresses set up by these loads should be practically constant at all pitch-line velocities on any given pair of gears.

The actual stresses set up in these tests are an appreciable amount above the compressive fatigue limit of the materials because the gears in these tests were run only about from three to

[1] Prepared by Prof. Earle Buckingham, director of experimental work for the Committee at Massachusetts Institute of Technology.

[2] The personnel of the A.S.M.E. Special Research Committee on Strength of Gear Teeth is as follows:

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Carl G. Barth, 229 Park Avenue, Prescott, Arizona.

Earle Buckingham, Professor, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Ralph E. Flanders, Manager, Jones & Lamson Machine Company, Springfield, Vt.

Arthur M. Greene, Jr., Dean, School of Engineering, Princeton University, Princeton, N. J.

Clarence W. Ham, Professor of Machine Design, University of Illinois, 115 Transportation Building, Urbana, Ill.

Charles H. Logue, *Secretary*, Consulting Engineer, 123 Clarke Street, Syracuse, N. Y.

Fred E. McMullen, Manager Cutter Department, The Gleason Works, Rochester, N. Y.

Edward W. Miller, Chief Engineer, Fellows Gear Shaper Company, Springfield, Vt.

Ernest Wildhaber, 1110 East 21st St., Brooklyn, N. Y.

NOTATION FOR TABLES 1-5

V = pitch-line velocity in ft. per min.
f = transmitted tooth load in lb.
k = calculated amount of separation of tooth profiles in in.
F = resulting impact load in lb.
S = corresponding max. specific compressive stress in lb. per sq. in.

TABLE 1—RUN AV. ALUMINUM PINION AND CAST-STEEL GEAR

Run No.	V	f	k	F	S
AV-112	1995	300	0.003370	1643	78,754
AV-114	1744	387	0.002228	1657	79,088
AV-117	1288	475	0.001454	1657	79,088
AV-125	696	1100	0.000255	2397	95,723
AV-131	207	1154	−0.000650	1412	73,008
AV-135	892	606	0.000351	1459	74,213
AV- 8[1]	1170	362	0.001305	1327	70,778

TABLE 2—RUN AW. PHOSPHOR-BRONZE PINION AND CAST-STEEL GEAR

Run No.	V	f	k	F	S
AW-102	2058	330	0.008728	2764	111,244
AW-105	1992	372	0.007449	2767	111,304
AW-107	1285	460	0.003431	2304	101,566
AW-109	1002	548	0.001888	2094	96,826
AW-111	845	728	0.000893	2086	96,642
AW-114	660	828	0.000324	1936	93,102
AW-117	597	909	0.000115	1930	92,957
AW-124	735	1257	−0.000045	2469	105,140
AW-130	525	1641	−0.000563	2555	106,955
AW-133	522	1748	−0.000639	2657	109,060
AW-135	490	1990	−0.000803	2858	113,120
AW- 8[1]	1200	472	0.003013	2252	99,952

TABLE 3—RUN AX. MANGANESE-BRONZE PINION AND CAST-STEEL GEAR

Run No.	V	f	k	F	S
AX-105	1872	378	0.008182	2633	108,676
AX-108	1964	391	0.006970	2739	111,344
AX-110	1382	483	0.003595	2417	104,027
AX-111	785	556	0.001184	1836	90,666
AX-117	762	1196	0.000054	2445	104,628
AX-120	503	1510	−0.000494	2390	103,444
AX-122	346	1871	−0.000824	2492	105,628
AX-126	106	2584	−0.001224	3163	119,003
AX-128	1068	613	0.001821	2235	100,034

TABLE 4—RUN BB. ALUMINUM-BRONZE PINION AND CAST-STEEL GEAR

Run No.	V	f	k	F	S
BB-30	196	2154	−0.001053	2391	103,466
BB-33	432	1794	−0.000825	2273	100,880
BB-36	741	1441	−0.000524	2183	98,863
BB-39	1257	1261	−0.000182	2324	102,006
BB-42	1775	1096	0.000196	2374	103,010

TABLE 5—RUN AY. MACHINE-STEEL PINION AND CAST-STEEL GEAR

Run No.	V	f	k	F	S
AY-103	204	2131	−0.000647	2438	130,970
AY-105	298	1714	−0.000497	2148	122,934
AY-108	675	1372	−0.000254	2242	125,595
AY-110	1005	1173	−0.000001	2345	128,448
AY-112	1479	993	0.000400	2499	132,598
AY-115	2639	828	0.001263	2843	141,431

[1] From Progress Report No. 10.

five minutes at a time. The evidence of failure of the tooth surfaces consisted of the presence of bright pitted holes of varying sizes and shapes, depending upon the material in the test pinion, and of the presence of fine particles of metal in the oil used to lubricate the gears. After each run where such pitting developed, the gears were run together under less severe conditions to partially restore the tooth surfaces by cold working. With the more ductile or plastic materials, the evidences of pitting were almost entirely obliterated in these polishing or burnishing runs. In other cases the original pitted holes were discolored and dulled by such burnishing runs so that the new pitted holes developed in further runs were readily distinguished by their brightness. The tooth surfaces were carefully examined through a magnifying glass after each run, yet it proved quite difficult at times to determine whether or not the pitting was truly commensurate on each test run. Several varying factors were involved to add to this difficulty. It is probable that in the earlier runs on any given pair the weaker sections of the material sheared out first. Again, with the continued cold working of the material in the burnishing

FIG. 1 ALUMINUM PINION
(Flaky particles, heavy scoring or abrasion at tip of teeth.)

runs, the actual physical characteristics of the material changed. The first series of runs were started at the higher speeds and lower loads. It soon seemed evident that the cold working under these conditions was not as thorough and effective as the cold working under heavier loads and slower speeds. This seemed probable because of the increasing difficulty of determining the limit loads when the lower speeds were reached. As a result, the later tests were started at lower speeds and heavier loads. These later runs were the most consistent in their results of any of the series. This was also probably due partly to the greater skill developed in the observers as regards the detection of more nearly commensurate signs of distress.

These tests were made by Messrs. W. R. Du Vernet and A. H. Shedd and reported in their thesis entitled "Limiting Wear Loads on Gear Teeth," submitted to the Massachusetts Institute of Technology in 1928.

These test results were as given in the following paragraphs. Data on the original runs of these gears, with the exception of Run BB, will be found in Progress Report No. 10. The aluminum-bronze pinion used for Run BB was received after the other tests had been completed.

RUN AV

Test pinion	3—18—14
Test gear	3—48—4
Aluminum pinion and cast-steel gear	
Measured error	0.0018 in.

The oil used on the first runs was of heavy body and dark in

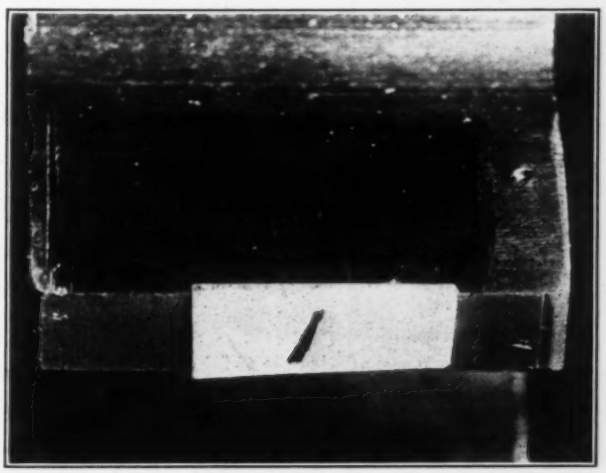

FIG. 2 PHOSPHOR-BRONZE PINION
(Fine particles, light abrasion at tip of teeth.)

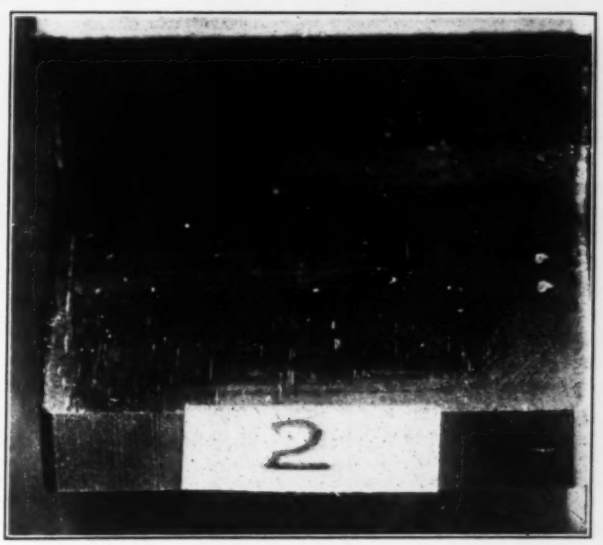

FIG. 3 MANGANESE-BRONZE PINION
(Heavier particles, heavier abrasion at tip of teeth.)

color. This made it difficult to detect signs of distress. At run AV-120 and until after run AV-125 the teeth were washed with kerosene just before stopping the run. This brightened up the whole surface of the teeth and washed off the small particles of metal which would otherwise be present. This made it difficult to judge of the condition of the tooth surfaces. A lighter oil was then substituted which gave much better results. The discoloring of this oil under the heavier loads was very noticeable and was taken as one of the indications of the limit load.

At limit-load conditions, flakes of aluminum were found in the oil film at the tips of the teeth. On the tooth surface were found very shallow and ragged pitted holes having bright, shiny bottoms.

This soft material cold worked readily after each test run, practically eliminating all signs of pitting and showing contact out to the tips of the teeth. These gear-tooth surfaces had been well cold worked in earlier runs. Fig. 1 shows the appearance of these surfaces after a limit-wear-load run.

The surfaces were tested for hardness with a modified scleroscope on both the worked and unworked sides. The unworked

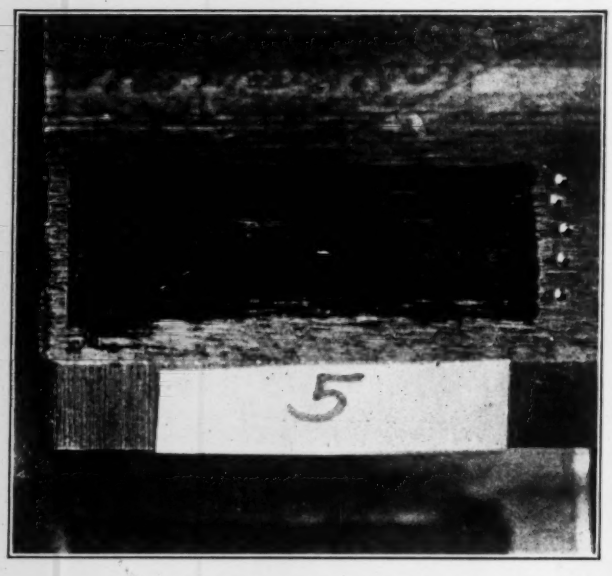

FIG. 4 ALUMINUM-BRONZE PINION
(Flaky particles, heavy abrasion at tip of tooth.)

side gave a reading of 35, while the worked side gave a reading of 44.

The limit-load runs are given in Table 1. The calculated maximum specific compressive stresses for these runs, excepting Run No. AV-125 which was manifestly out of line with the others, range from about 73,000 to 79,000 lb. per sq. in. This value was about 70,000 lb. per sq. in. on the original run AV-8. The increase may be due to the additional cold working which the surfaces of the teeth received in these later runs. As noted before, these values are all above the fatigue-limit load. Judging from the results of other types of fatigue tests, it seems probable that the fatigue limit may be from 60 to 75 per cent of these test values. This might make the fatigue limit for aluminum after it has been cold worked about 45,000 lb. per sq. in. in compression.

RUN AW

Test pinion	3—18—12
Test gear	3—48—4
Phosphor-bronze pinion and cast-steel gear	
Measured error	0.0035 in.

The first runs with this pinion were made with lighter loads and higher speeds. Successive runs were made with heavier loads at slower speeds. At failure, the tooth surfaces showed very fine pinholes and the oil was discolored by very fine particles of bronze. These particles were not flaky as with aluminum.

This material cold worked appreciably after each limit-load test run. These tooth surfaces had also received some cold working during the original test runs. Fig. 2 shows the appearance of these tooth surfaces after a limit-load run.

When tested for hardness, the unworked side gave a reading of 32, while the worked side gave a reading of 36.

The limit load runs are given in Table 2. The calculated maximum specific compressive stresses on these runs ranged from about 93,000 to 113,000 lb. per sq. in. Assuming as before that the fatigue limit is about 60 per cent of these test values, we should have for this material in its cold-worked state a compressive fatigue limit of about 60,000 lb. per sq. in.

RUN AX

Test pinion	3—18—13
Test gear	3—48—4
Manganese-bronze pinion and cast-steel gear	
Measured error	0.0035 in.

The first runs on this pinion were made with lighter loads at the higher speeds. At failure, the tooth surfaces were dulled. At some points they had the appearance of hammered metal, and small pitted holes could be seen, while the oil was discolored by small particles of the material. Some abrasion is present here, and the contact did not extend to the tips of the teeth. Fig. 3

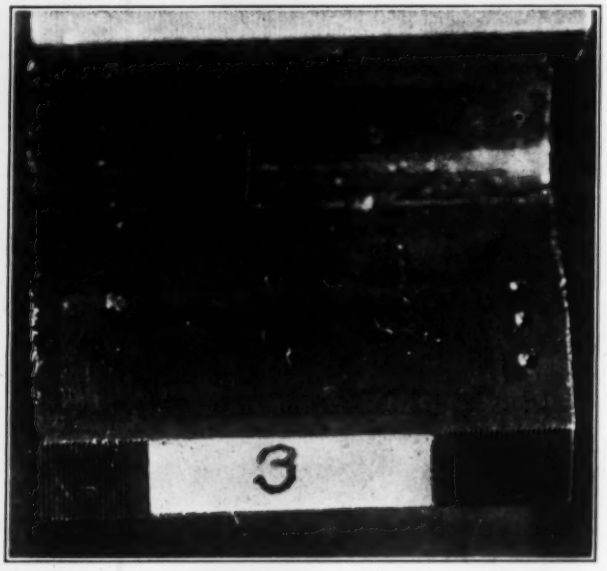

FIG. 5 MACHINE-STEEL PINION
(Very fine particles, very light scratching or abrasion near tip of tooth.)

shows the appearance of the tooth surfaces after a limit-load run.

When tested for hardness the unworked side gave a reading of 44, while the worked side gave a reading of 45.

The limit-load runs are given in Table 3. The calculated maximum specific compressive stresses on these runs ranged from about 119,000 to 90,000 lb. per sq. in. Assuming as before that the fatigue limit is about 60 per cent of these test values, we should have for this material in its cold-worked condition a compressive fatigue limit of about 60,000 lb. per sq. in.

RUN BB

Test pinion	3—18—17
Test gear	3—48—4
Aluminum-bronze pinion and cast-steel gear	
Measured error	0.0016 in.

The first runs on this pinion were made with the heavier loads at the slower speeds so as to cold work it as thoroughly as possible in the early runs. At failure the oil was discolored by small

flakes of bronze, and shiny pitted holes of irregular shape were apparent. Fig. 4 shows the appearance of the tooth surfaces after a limit-load run. Here also the contact did not extend to the tips of the teeth.

When tested for hardness, the worked side of the teeth gave the same reading of 42 as the unworked side. This material was not ductile enough to be capable of receiving any measurable amount of cold working.

The limit-load runs are given in Table 4. The calculated maximum specific compressive stresses on these runs ranged from about 99,000 to 103,000 lb. per sq. in.—the most consistent of all the runs. Assuming as before that the fatigue limit is about 60 per cent of these test values, we should have for this material a compressive fatigue limit of about 60,000 lb. per sq. in.

RUN AY

Test pinion	3—18—11
Test gear	3—48—4
Machine-steel pinion and cast-steel gear	
Measured error*	0.0015 in.

The first runs on this pinion were made with the heavier loads at the lower speeds. At failure the oil was discolored by minute particles of steel, and the tooth surface showed very minute holes as though caused by a very fine-pointed tool.

The contact did not extend far enough toward the tips of the teeth to permit a measurement of the hardness to be made on the cold-worked surface. Fig. 5 shows the appearance of these tooth surfaces after a limit-load run.

The limit-load runs are given in Table 5. The calculated maximum specific compressive stresses on these runs ranged from about 123,000 to 141,000 lb. per sq. in. Assuming as before that the fatigue limit is about 60 per cent of these test values, we should have for this material in its cold-worked state a compressive fatigue limit of about 80,000 lb. per sq. in.

SUMMARY

These tests indicate the value of ductility, as measured by its ability to be cold worked, in materials used for gears. The suggested values for the fatigue limit in compression for bronzes given in the preceding paragraphs are based on the average of the test runs. If the test loads are plotted against the test speeds, these curves will show a decided offset for phosphor bronze and manganese bronze when the lower speeds are reached. These offsets are possibly due to the increased physical properties of these materials because of cold working. Under these conditions the proper values for these bronzes might be taken as follows:

Material	Maximum specific compressive stress, lb. per sq. in.	Fatigue limit in compression, lb. per sq. in.
Phosphor bronze	110,000	66,000
Manganese bronze	105,000	63,000
Aluminum bronze	100,000	60,000

These tests also throw some light on the phenomena of pitting. Incipient pitting on heavily loaded gears is probably caused by the shearing out of the weaker particles of the material. If the loads do not exceed the fatigue limit for the sound material, this incipient pitting will cease and should be no cause for alarm. If the loads are beyond the fatigue limit, however, this pitting will continue until the tooth profiles are destroyed.

Some abrasion was present in these tests, and was probably caused by the fine particles of material carried in the oil as a result of pitting. This abrasion seemed to be most pronounced when the particles of material were larger, or flaky. This would indicate the desirability of either straining the oil used on heavily loaded gears or else changing it frequently after the original installation of such gears until after this incipient pitting has ceased.

The results of these tests also give us increased confidence in the qualitative accuracy of the mathematical analysis developed in Progress Reports Nos. 4 to 8, inclusive. Thus far the tests have been made with gears of about 1 in. circular pitch. It is proposed to carry out further tests with gears of finer pitch, both for the amount of separation as measured by the breaking of the electrical circuit through the teeth and also for similar limit-wear-load tests.

Apparatus for obtaining values of the elastic deformation of the teeth under load to be used on the testing machine has also been designed and built by Mr. Lewis, and tests to obtain experimental values of this deformation will soon be made to check the calculated values thus far used in these analyses.

The Engineers' Registration Law in Colorado

AT A MEETING of the Colorado Section of the A.S.M.E., held in Denver, February 22, 1929, Prof. John A. Hunter,[1] a member of the Colorado State Board of Examiners for Engineers and Land Surveyors reviewed the administration and operation of the Engineers' Registration Law in part as follows:

The Colorado law has been in effect for ten years. The first Act stipulated that engineers should be "licensed," but in 1927 the Act was amended and the term "Licensed Engineer" was superseded by the term "Registered Engineer."

The entrance fee in Colorado is $15, with an annual renewal fee of $5. Fees are refunded to applicants who are rejected by the Board. The fees received are not turned into the General Fund, and any money received in excess of the funds necessary to administer the law may be used to purchase books for the City Engineering Library. The cost of administering has averaged only about 4 per cent of the revenue, and to date a surplus from this fund of approximately $20,000 has been used to buy books for the City Engineering Library. The library often adds several times the amount of the fund contributed by the Examining Board, and the result is that Denver boasts of having the fourth best engineering library in the United States.

When the law was first enacted, a "grandfather's clause" was inserted whereby any person who had been practicing engineering would be granted a license on request, and without examination.

Now, the burden of proof rests on the applicant. The powers of the Board are such that they can grant a "registration" merely on the record of accomplishments of the petitioner; they can request the applicant to appear for oral examination, or they can require a full written examination.

The Colorado law provides that the Board is entitled to the services of the attorney general, and also provides that the secretary of the Board may be authorized to submit evidence of any violation of the Act to any prosecuting attorney and prosecute the offender, acting both as an individual and as secretary of the Board. The law provides a penalty of from $100 to $500 or three months imprisonment, or both fine and imprisonment.

Colorado grants reciprocity to an engineer moving into the state from another whose standards are satisfactory to the Board. If such an engineer comes to Colorado temporarily but remains a resident of the other state, he may practice engineering a total of 90 days in one year, within the state, and remain exempt from the provisions of the Act.

A surveyor, draftsman, or engineer who works under the supervision of a "Registered Engineer" is exempt from the provisions of the Act on work so done.

The Board is making progress in administering the Engineers' Registration Law, and many tradesmen who illegally designated themselves "Engineers" are removing the prefixes and suffixes from cards, windows, and automobiles.

The Engineers' Registration Law in Colorado is functioning as well as any similar state law, and probably as well as any like national law. The public demand that engineering and land surveying be done by a "registered" man is increasing, and there is every indication that the law has the approval of both the public and the engineering profession.

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[1] Professor of Mechanical Engineering, University of Colorado. Mem. A.S.M.E.

Wanted: An Unpractical Education

By JOHN C. PARKER,[1] BROOKLYN, N. Y.

I HAVE a son who is nearly 13 years old. You and I have a common problem with relation to that boy, I as the parent, you as possible teachers; or if a former teacher may momentarily revisit the pale glimpses of the moon, I shall identify in my own person both the teacher's viewpoint and that of the parent. Since prior to my seven-year period as a teacher I was an employer and have returned to that relationship, may I try to talk in all three capacities. Again, as a workman who has been somewhat educated may I talk as well from the point of view of that least considered victim in the process, the graduate himself.

I believe that the true interests of all parties of this process, the student, the parent, the employer, and the teacher—significant in the order named—are identical, that what is broadly good for one is to the best interest of all.

For this boy of mine, for his greatest usefulness in life and for his personal happiness, for the gratification of my hopes and ambitions for him, for what he can do in the world, serving the kind of employer I hope he will have and for the biggest satisfaction of the teachers under whom he may elect to study, I hope he can be given through the years of high school and college the sort of a thing that is commonly called an unpractical education.

For this boy of mine, for his greatest usefulness in life and for his personal happiness, for the gratification of my hopes and ambitions for him, for what he can do in the world, serving the kind of employer I hope he will have, and for the biggest satisfaction of the teachers under whom he may elect to study, I hope he can be given through the years of high school and college the sort of a thing that is commonly called an unpractical education.

Granted that just so much can be accomplished in sixteen or eighteen years of formal schooling, I want those things to be of such a character that my son can use them in whatsoever field of human endeavor may be suited to him and may offer itself, and if he chooses some particular range of studies I want to be sure that, aside from and superior to the subject-matter, those courses shall have a content which shall do things to him in the way of developing intellectual vigor, standards and ideals, and mental processes which can be brought to bear on any of the problems of life.

The Useless in Education Really of the Highest Utility

I am basing this hope on the firm conviction that the kind of stuff that is usually understood as practical is actually most unpractical, and that the kind of thing that may be styled useless really has the highest utility.

There is a persistent demand from parents and employers, from trade associations and from donors, from the makers of curricula, and from the youngsters themselves whether in primary, secondary, or university institutions, that pupils be given something useful, meaning thereby, I suppose, something with which they can earn a living.

In so far as this is in protest against a snobbish classicism, I sympathize with it most fully. I have little patience with the idea that subject-matter loses its cultural or educational value merely because it is related to an honest world of affairs of physical fact and of live processes. On the contrary, a vital and vigorous education can come only through being related to life.

My complaint would be rather that training youth to earn a living is not education at all; second, that a specific training may keep the youngster from earning the best kind of a living; and third, that it can't be done in school anyhow.

I assume that it is not a legitimate function of educational institutions to take the funds of society as a whole to fit certain particular individuals to earn a living through advantages not universally enjoyed. On the other hand, I conceive the real purpose back of state support, back of the social support of education, to be the fitting of students to live richly and fully and to contribute most broadly to the welfare of the social group who have paid for their education.

Whether this be the true purpose of education or not for this boy of mine, I am considerably more interested in whether he shall be able wisely to spend and fully to enjoy what he earns than I am in the amount of those earnings or the ease with which they are acquired.

I would infinitely prefer that education fit him for happiness and decency in poverty than for wealth acquired through the sacrifice of himself and his character.

Grant that I am wrong in this. I know perfectly well that his young mind will absorb only a certain amount and that if particular training in a too narrowly defined art be given him, life may perpetrate one of its ghastly jokes in presenting narrow opportunity along that line and big opportunities in fields for which he has not been trained at all.

Any one who has lived in an actual world has seen literally thousands of cases in which men, young and old, have been trained in an art which has become obsolete and have seen the victims forced to degrade their social usefulness through lack of adaptability to changed conditions. We have seen cases in which the fields chosen by parents or advised by teachers or selected by the students have not in the sequel proved what they were thought to be, and we have seen men left standing in forward-moving organizations merely because they had not that breadth of fundamental training which would enable them to move with the current.

Granted, then, that just so much can be accomplished in sixteen or eighteen years of formal schooling, I want those things to be of such a character that my son can use them in whatsoever field of human endeavor may be suited to him and may offer itself, and if he chooses some particular range of studies I want to be sure that, aside from and superior to the subject-matter, those courses shall have a content which shall do things to him in the way of developing intellectual vigor, standards and ideals, and mental processes which can be brought to bear on any of the problems of life.

Mathematics a Spur to Imagination

I hope he will be interested in pure mathematics, and I don't care whether he is as ignorant as his sire concerning the equation to or the shape of a lemniscate; that really doesn't matter after all and the world probably would have been quite as rich had the curve never been discovered, but if the youngster meets it I

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[1] Vice-President in Charge of Engineering, Brooklyn Edison Co., Inc. Mem. A.S.M.E.

Address at a meeting of the Society for the Promotion of Engineering Education, Brooklyn, N. Y., December 8, 1928.

want him to be able to see some sheer physical beauty in the grace of the thing. I hope that his imagination will be arrested when he discovers that the shifting of the constants in the equation of a hyperbola creates a beautiful and moving series of exquisite curves all tied together at infinity, passing through two intersecting straight lines and filling voids in unoccupied quadrants. Here will be something that will arouse his imagination, that will teach him that order which is heaven's first law, which will enable him to project his mind beyond the immediate and the particular into a wondrous field of generalized relationships.

These values in his mathematical studies will be as great whether he follows the law, preaches the gospel, administers to the physical needs of the sick, or runs a merchandising establishment.

And if he elects to take a course in engineering I hope that he will bring out of it a knowledge of the conduct and behavior of materials and of the processes by which industrial human progress has taken place, which will enable him to understand a life which has its very foundations in the creative works of organized industrial society. I shan't, however, be very much concerned with whether he has been taught some particular form of valve gear or somebody's pet formula for buttoning up a riveted joint.

Real Values of Courses in Pure and Applied Science

At this point let me say just one word about the real values in all these courses in pure and applied science. They deal or should deal with objective truth rather than with speculation or opinion. If bigly taught they will promote a higher type of imagination than ever could be had from subject-matter that concerns itself only with speculation. It is a finer vision that can constrain itself to things proved and learn from them the great generalized truths of the universe, that can perceive the romance back of the lifting of a continent from the ocean bed—this is an infinitely finer type of vision than the hothouse variety that can find beauty and romance only in artificiality, be it never so exquisite.

But beyond all this, our scientific and professional courses have a tremendous advantage in their objective character. Being that, if they do no other thing, they should develop love of the truth, not moral integrity alone but intellectual candor, which in my mind is pretty close to the beginning and end of all the virtues. If you teachers will do some things of this sort for my son I know that he will approach life unafraid, that he won't try to fool himself into believing that his selfish desires are the will of Jehovah or that he is more important than his fellow-men.

If imagination and integrity can without preaching be developed in our professional courses, such education will be the more persuasive because it has been born of things to which it might not superficially have been suspected to be germane.

I have suggested that no school can give a narrowly practical training. Any one who knows both teaching and practice knows this full well. The life of the student is artificial—and should be. He is forced to march more or less in lockstep with his fellow-students through a more or less definitely-laid-out curriculum. Life doesn't work that way. Individuals in the ever-changing exigencies of a real world forge ahead or drop behind or move side by side up to a point of divergent influence. Decent or brutal competition exists. Some assume leadership—others follow. The whole atmosphere of school and of life is necessarily and essentially different.

The Designer's Work Primarily in the Discovery and Statement of His Problem

Practical design concerns itself with intricately organized social and economic processes: the most trifling engineering device must be designed for production under the peculiar conditions and restraints of an actual factory, to be marketed through real and frail human channels, and to be used by actual ultimate consumers. Ninety per cent of the problems of a designer lie in the wise determination of these and other constraining facts, in the selection of the field which he shall endeavor to cover, and in the satisfaction of others that his determinations are sound. His work is primarily in the discovery and statement of his problem. No school can ever hope even remotely to assemble an environment of actuality about any problem—of necessity it must formalize an artificial problem if indeed it would avoid giving the student a most unpractical impression that his subsequent problems in actual life will come to him all neatly wrapped up in packages, labeled, and classified.

Grant even that real problems could be introduced within the school walls, the question yet remains as to what value attaches to the specific practical information that is gotten from solving them. Any professional work is a live thing, related to rapidly changing life. The ink will not have time to dry on the student's diploma before the quantitative facts, social emphasis, and the problems that are crying for solution shall have changed. What point, then, in teaching the youth formulas, data, and processes howsoever accurately if necessarily obsolete? This were a most unpractical practicality.

But, you urge, the world won't take our goods unless we purvey to its needs. Industry insists that we must turn out our graduates to its end. Maybe so—I can't ask you to take my personal wishes as an index of what the world at large wants, but for what they are worth let me state them here. As an administrator I am not particularly desirous of having young men come to us full of facts which would be slightly interesting if they were right, but which, in the main, will have to be unlearned because they just aren't so. If a teacher can get hold of the facts of my industry in order to communicate them to his students he will have to get hold of those facts from the industry itself, and so, if you please, the student will be merely bringing back to us, a little late and a little shopworn, the specific facts that have arisen with us.

Put it the other way round. We shall get stuff thoroughly codified into a practice which can be carried out by routine workers long before it can be formulated into school instruction. We want something very much bigger than this. We need young men of keen perception, sound and orderly analytic ability, of sympathy and of understanding, to analyze the facts as they arise from day to day, to draw new conclusions from them, to generalize these conclusions into canons of the truth, and to devise new practicalities of putting them into effect. This sort of thing, in that it pays big dividends or increases the social value of our service, is practical with a vengeance, and it is the sort of thing for which every industry and every profession and every art is ahungered and athirst whether it recognizes the need or not.

Teaching of Practice May Be the Teaching of Bad or Obsolete Things

Let it be thoroughly understood, too, that the teaching of practice may be the teaching of obsolete or bad things. All practice contains some elements that are not worthy to be continued, and some practice is positively wrong. The major part of the life work of any man must be to create new practice to correct and to improve what exists.

The teaching of practice tends to the continuation of evils rather than to the type of mind that makes for betterments.

None of the world's great discoveries and inventions have come by the process of yielding up, like a squeezed sponge, these things which the mind has soaked up, but rather as the result of critical and creative and impatient mentalities.

What little of practical training may be necessary can very quickly be grasped by a young man fundamentally and thoroughly educated through his contacts in the only school of practice—life itself.

I am telling you of the need of my industry and of my profession as I see it, and telling you of what I personally would ask of the teaching profession. Is it a practical program of education to make education unpractical? Will the world accept the goods which the teacher is offering? My answer must be the very practical one of experience during seven years as an educational administrator. During the period to which I refer, the staff of which I was in charge endeavored solely to give a broad and fundamental education, concerning ourselves much more with what we did with our students than with what incidental facts they accumulated. This was done in the face of criticism from other teachers, complaint by the students, and insistent practical demands from industry. The parents happily left us alone. I say this program was adopted in the face of criticism: that was, initially. Enrolment dropped and gradually mounted considerably above what it had been before the elimination of every practical course offered by our department. We didn't at any stage in the game have any difficulty in finding places for our students with the people with whom we wanted them to connect; indeed, during the lean years of 1921 and 1922 the difficulty was rather to keep the youngsters from being inflated by too much solicitation on the part of employers who had had samples from previous crops. Six years later I find many of the boys who went through that kind of a process occupying rather unusually distinguished positions in industry, and am glad to say that I have been able and willing to use several of them in my own organization.

What industry will accept is altogether a question of having faith in the program and the courage to carry it through.

The Duty of the Teaching Profession

And now for the teacher himself, what shall we say? Must he always listen to the cheap deprecation of his calling? Shall he concern himself with the stupidity of a world that damns with the label "pedagogue?" Is his way out to attempt to do something practical and useful, to go through the motions of practicality necessarily with his tongue in his cheek the while, or will he recognize that it is better to teach well those things that can be taught than to teach badly the things which have a glamorous glitter on the pages of a college announcement? Can he not—*must* he not—recognize that it is more important to educate and to develop men for life than it is to satisfy the whims and caprices of students or of possible employers or even to offer those courses which a president or a board of trustees ask of him as a cheap form of parlor trick? Again, may one be just a little practical in discussing this unpractical subject. One hears much of the poor pay that is given to the teaching profession. In part this is right and in part the just suffer with the unjust, but I rather suspect that were our schools to have more faith in education and to be less compliant in giving functional training they would deliver goods of a kind that the world really wants, and that the natural law of supply and demand would insure vastly more adequate compensation for teachers as teachers than it will give to school men who make a most inadequate pretense of being anything but what they are.

And so it is, gentlemen, that as the victim of a university education, as an employer, as a father, and as a teacher I am putting out my advertisement calling for an unpractical education in the full assurance that the right kind of unpractical education is the only kind that is most practical; and just in proportion to the shortness of the period that the individual can spend in school would I lay more stress on his getting from school those values which can be had nowhere else, so that the least favored shall have the assurance of a more nearly even start with those who can spend more time and perhaps in the graduate's school develop particularized training.

All of which is very unpractical unless one suggests an answer to the question—"What are you going to do about it?" Well, I have no faith that these remarks of mine are going to cause boards of trustees and curriculum committees to change their curricula over night, but I have a hope that those of you who have some faith in the theoretical aspects of education and who have somewhat of a pastoral interest in the boys committed to your charge will recognize that however practical the educational machine in which you are a cog, you can individually so direct the conduct of your courses that your students in later life may arise and call you blessed for having given them something useless—something on which to build for themselves.

Power Resources of the World

NO ONE can tell with any degree of certainty what the world's coal resources are. Estimates fluctuate between 6,835,000 million tons and 10,800,000 million tons, the balance of opinion tending toward the lower figure. But for a considerable number of important industrial countries the survey under consideration establishes what may be regarded as fairly accurate statistics. The main point at issue is that the course of production, which has been almost stationary since 1913, has imposed no strain on the resources available. Thus in 1927 the total coal output of the world was 1,276,000,000 tons, or rather less than one four-thousandth part of the world's reserves on the most conservative basis. In other words, coal reserves may be exhausted at the present rate of production in about 4000 years. Rumors of exhaustion of oil within seven years have alternated with confident statements that there is no limit to the supply available, while comparison between production in 1927 and the estimated resources given provisionally by the United States Geological Survey shows that exhaustion may come within forty years. Against this, however, stands the affirmation of Dr. Egloff, namely, that "from the beginning of production on a significant scale in 1857 to the end of 1927, the oil fields of the world produced 16,000,000,000 barrels of petroleum. This, however, is only a fraction of the oil resources of the producing areas, for it is estimated that, at the most, 20 per cent of the oil in the ground is brought to the surface by present methods of recovery." The whole matter belongs more to speculation than to exact science.

Perhaps the greatest progress has been made toward accurate assessment in connection with water power, but difficulties have arisen regarding methods. According to the World Power Conference of 1924, water-power resources amounted to 381,000,000 hp., and according to the United States Geological Survey, to 445,000,000 hp. Investigations show very considerable differences between official figures for a number of leading water-power countries, such as Russia, Japan, Canada, Dutch East Indies, Sweden, Norway, France, Germany, and Poland. The result is that estimates and methods are in the melting pot and much coordination must take place before progress can be reported.

At the present time the world's output of electrical energy is 190,000 million units per annum, of which the United States is responsible for less than half and Britain for about 5 per cent. Even now the rate of progress in Britain, owing to industrial depression, is lower than in the United States, Germany, Canada, Italy, or Switzerland. Like Britain, the larger countries of Europe and the Dominions are all committed to ambitious schemes of electrification with the object of effecting a radical transformation in their industrial position.—*The Engineer*, April 12, 1929, p. 411.

Callendar's Steam Tables

OUR readers will recall that in February we published a group of papers and reports dealing with recent researches in the properties of steam at high pressure and a reproduction of a new total heat-entropy diagram which extended beyond the critical region. Those who have followed experimental investigations, and particularly readers of the British weeklies, *Engineering* and *The Engineer*, know of the work done by Callendar in this field of research. Much interest will be aroused, therefore, in the publication in the Proceedings of the Institution of Mechanical Engineers of Professor Callendar's "Extended Steam Tables." From *Engineering* of May 10 we reproduce three tables which accompany Professor Callendar's report and which give the properties of saturated and superheated steam covering the range up to 4000 lb. per sq. in. and 1000 deg. fahr.

In the opening paragraphs of his paper as published in *Engineering*,[1] Professor Callendar says:

"With the assistance of the British Electrical and Allied Industries Research Association, it recently became possible to make direct measurements of the total heat of both water and steam at pressures up to 4000 lb. per sq. in., and temperatures up to 750 deg. fahr. These included the whole of the critical region, in which no heat measurements had previously been made, and proved that the objection to the Joule-Thomson equation (namely, that it was incapable of representing the complex phenomena of the critical state) had no foundation in fact. The new experimental data proved to be quite inconsistent with the van der Waals theory, which had been universally accepted for more than fifty years, but fell naturally into line with the fundamental basis of the Joule-Thomson equation, as first applied to steam by the author in 1900.

"This fatal objection having been removed, a general account of the theory and equations, as applied to the critical state, was communicated to the Royal Society in 1928,[2] and a set of skeleton steam tables, calculated from the modified equation, was forwarded to the Research Association at the same time. These tables are now published with some additional details and explanations. They are not intended to be final, but are reproduced as a basis of discussion and comparison, with the object of inviting criticisms and suggestions from other workers."

In describing his experimental apparatus and the methods of taking and reducing observations, Dr. Callendar writes:

Three principal types of apparatus were employed as follows:

(1) A differential electric calorimeter for measuring the specific heat of steam at atmospheric pressure as required for the reduction of experiments by the throttling method at high superheats.

(2) A differential throttling calorimeter for measuring the total heat of steam at any temperature and pressure within certain limits, by throttling to atmospheric pressure and observing the temperature.

(3) A jacketed condenser, with high-pressure pocket and throttle, for directly measuring the total heat of water or steam at any pressure and temperature, by throttling to atmospheric pressure and measuring the rise of temperature of a steady flow of cooling water in the condenser.

Methods (1) and (2) had the advantage that the external heat loss could be determined at each observation. They could not be employed if either the initial or final steam was wet, and were liable to systematic errors in the neighborhood of saturation. Method (3) had the advantage of being equally applicable to water and wet steam, and of being independent of any assumption with regard

EXTENDED STEAM TABLES.

TABLE Ir.—Properties of Saturated Steam in Foot-Pound Fahrenheit Units on a Temperature Basis.

Temperature, deg. F.	Pressure, lb. per square inch.	Volume, cub. ft. per lb.	Entropy, B.Th.U. per lb. per deg. F.		Total and Latent Heat, B.Th.U. per lb.		
t	p	V	ϕ_w	ϕ_s	A	L	H
400	249·4	1·8572	0·5617	1·5338	375·1	831·3	1206·4
410	279·2	1·6622	0·5794	1·5244	386·6	822·0	1208·0
420	311·6	1·4939	0·5917	1·5150	397·0	812·2	1209·2
430	346·9	1·3459	0·6043	1·5058	408·2	802·2	1210·4
440	385·1	1·2150	0·6167	1·4967	419·6	791·6	1211·2
450	426·5	1·0989	0·6289	1·4876	430·8	781·0	1211·8
460	471·1	0·9950	0·6412	1·4786	442·1	770·0	1212·1
470	519·2	0·9033	0·6536	1·4697	453·6	758·8	1212·4
480	571·0	0·8209	0·6658	1·4607	465·2	747·1	1212·3
490	626·5	0·7471	0·6780	1·4517	476·9	734·9	1211·8
500	686·1	0·6807	0·6901	1·4428	488·9	722·2	1211·1
510	749·7	0·6211	0·7024	1·4337	500·9	709·2	1210·1
520	817·7	0·5669	0·7148	1·4246	513·4	695·2	1208·6
530	890·2	0·5182	0·7271	1·4154	525·7	681·1	1206·8
540	967·5	0·4739	0·7395	1·4060	538·3	666·3	1204·6
550	1049·6	0·4336	0·7519	1·3965	550·9	651·1	1202·0
560	1136·8	0·3966	0·7644	1·3867	564·2	634·6	1198·8
570	1229·4	0·3626	0·7769	1·3767	577·6	617·3	1194·9
580	1327·5	0·3317	0·7899	1·3664	591·3	599·3	1190·6
590	1431·9	0·3029	0·8029	1·3556	605·4	580·1	1185·5
600	1542·0	0·2764	0·8161	1·3446	619·7	560·0	1179·7
610	1658·0	0·2518	0·8296	1·3330	634·7	538·8	1173·0
620	1781·0	0·2282	0·8433	1·3207	649·8	515·5	1165·3
630	1911·0	0·2073	0·8573	1·3076	665·8	490·6	1156·3
640	2049·0	0·1869	0·8719	1·2937	682·5	463·5	1146·0
650	2195·0	0·1676	0·8876	1·2785	700·8	433·3	1134·1
660	2351·0	0·1490	0·9041	1·2618	719·9	400·2	1120·1
670	2516·0	0·1307	0·9216	1·2431	740·6	362·7	1103·3
680	2693·0	0·1124	0·9424	1·2216	764·9	317·7	1082·6
690	2886·0	0·0936	0·9676	1·1958	793·9	262·9	1056·8
700	3099·0	0·0731	1·0034	1·1629	833·5	188·7	1022·2
705·2	3222·0	0·0607	1·0285	1·1404	867·2	130·4	997·6
707	3268·0	0·0560	1·0407	1·1311	882·0	105·4	987·4
710	3350·0	0·0539	—	—	883·2	84·3	967·5
716	3563·0	0·0453	—	—	872·5	20·7	893·2
717	3650·0	0·0413	1·0086	1·0086	846·0	0·0	846·0

TABLE IIr.—Properties of Saturated Steam in Foot-Pound-Fahrenheit Units on a Pressure Basis.

Pressure, lb. per square inch.	Temperature, deg. F.	Volume, cub. ft. per lb.	Entropy, B.Th.U. per lb. per deg. F.		Total and Latent Heat, B.Th.U. per lb.		
p	t	V	ϕ_w	ϕ_s	A	L	H
400	443·8	1·1712	0·6212	1·4933	423·7	788·1	1211·8
450	455·4	1·0419	0·6357	1·4827	437·0	775·1	1212·1
500	466·1	0·9380	0·6487	1·4732	449·1	763·2	1212·3
600	485·4	0·7805	0·6722	1·4559	471·6	740·4	1212·0
700	502·1	0·6672	0·6929	1·4407	491·6	719·5	1211·1
800	517·5	0·5804	0·7117	1·4269	510·1	699·0	1209·1
900	531·3	0·5120	0·7288	1·4142	527·4	678·9	1206·3
1,000	544·1	0·4570	0·7443	1·4021	543·6	659·8	1203·4
1,200	566·9	0·3727	0·7734	1·3798	573·4	622·7	1196·1
1,400	587·1	0·3111	0·7992	1·3587	601·3	585·6	1186·9
1,600	605·1	0·2635	0·8230	1·3386	627·3	548·7	1176·0
1,800	621·5	0·2255	0·8454	1·3186	652·4	511·4	1163·8
2,000	636·5	0·1936	0·8669	1·2985	676·8	473·0	1149·8
2,400	663·1	0·1433	0·9098	1·2561	726·3	388·8	1115·1
2,800	685·4	0·1029	0·9556	1·2078	780·4	290·6	1071·0
3,200	704·4	0·0645	1·0231	1·1463	861·7	144·5	1006·2

[1] *Engineering*, vol. 127, nos. 3303 and 3304, May 3 and 10, 1929, pp. 546 and 595.

[2] Proc. Roy. Soc., 1928, vol. cxx, p. 460.

to the specific heat of steam. It required, however, a very exact knowledge of the variation of the specific heat of water at ordinary temperatures, which had previously been determined with this object by two independent methods.

The observations had not at that time (1926) been extended beyond 1000 lb. per sq. in. pressure with the first electric boiler. Upward of fifty results for the total heat, between 800 lb. and 1000 lb. per sq. in., from saturation up to 250 deg. fahr. superheat, were plotted on a large-scale diagram by a difference method, and showed good agreement between the throttling and condenser methods over the whole range. The results at high superheats, such as would necessarily be employed in practice, also agreed remarkably well with the Enlarged Tables representing the original equations of 1902. It appeared, however, that the results in the neighborhood of saturation were liable to vary with the purity and quality of the steam, and with the rate at which it was heated or cooled before entering the apparatus. These effects required a good deal of investigation before the equations could be extended to higher pressures, but explained many of the difficulties encountered by previous observers in the critical region, and indicated the manner in which such sources of error in the experiments might be avoided. In investigating complicated effects of this kind, it is necessary to compare experiments made under different conditions, which should be varied as widely as the method of measurement will allow.

Each observation by itself must possess a high order of accuracy, and be free from accidental or instrumental errors, if any success is to be achieved in the interpretation of the results. It will readily be understood that it would be impossible, within any reasonable compass, to give a complete analysis of the observations undertaken with this object. It must therefore suffice for the present to give a few examples illustrating the results obtained in investigating one of the most difficult points, namely, the effect of air and other impurities on the equilibrium between steam and water in the region beyond the critical point, where the effect of small impurities is most pronounced and most difficult to determine. The observed effects are probably due to the formation by the impurity of complex molecules with the steam, and have been interpreted on these lines by the author in a paper "On the Vapor-Pressure of Solutions." Similar anomalies were observed in measuring the specific heat of steam near saturation. These phenomena may give rise to systematic errors near the critical point, where they are much too large to neglect owing to the smallness of the latent heat.

Further interest attaches to these tables in view of the conference to be held this month in London which will be attended by research workers from Great Britain, Europe, and this country interested in the physical properties of steam. As announced in the May 7 issue of the *A.S.M.E. News*, the London conference will be attended by Messrs. Orrok, Davis, Keyes, Dickinson, Osborne, and Keenan.

EXTENDED STEAM TABLES.

TABLE IIIF.—Properties of Superheated Steam in Foot-Pound-Fahrenheit Units at Pressures from 400 lb to 4,000 lb.

Temperature t on the Fahrenheit scale. Total heat H in B.Th.U. per lb. Volume V in cubic feet per lb. Entropy ϕ in B.Th.U. per lb. per deg. F.

t	H	V	ϕ
P = 400 lb. per square inch.			
443·7°	1211·8	1·1712	1·4933
450	1216·0	1·1841	1·4983
500	1249·8	1·2898	1·5345
550	1281·0	1·3870	1·5664
600	1310·4	1·4788	1·5947
650	1338·8	1·5670	1·6209
700	1366·3	1·6528	1·6451
750	1393·0	1·7364	1·6677
800	1419·4	1·8182	1·6890
P = 500 lb. per square inch.			
466·0°	1212·3	0·9380	1·4732
500	1237·4	1·0007	1·4998
550	1271·2	1·0847	1·5341
600	1302·4	1·1627	1·5643
650	1332·1	1·2365	1·5916
700	1360·5	1·3076	1·6167
750	1388·1	1·3762	1·6400
800	1415·1	1·4435	1·6619
850	1441·5	1·5092	1·6824
P = 700 lb per square inch.			
502·1°	1211·1	0·6672	1·4407
550	1249·8	0·7361	1·4802
600	1285·4	0·7997	1·5147
650	1318·1	0·8578	1·5448
700	1348·8	0·9126	1·5719
750	1378·1	0·9647	1·5966
800	1406·4	1·0149	1·6196
850	1434·0	1·0640	1·6410
900	1461·0	1·1121	1·6611
P = 900 lb. per square inch.			
531·3°	1206·3	0·5120	1·4142
550	1224·5	0·5371	1·4321
600	1266·5	0·5953	1·4728
650	1303·1	0·6459	1·5065
700	1336·5	0·6921	1·5359
750	1367·7	0·7354	1·5623
800	1397·6	0·7767	1·5865
850	1426·3	0·8165	1·6089
900	1454·2	0·8552	1·6298
P = 1,200 lb. per square inch.			
566·9°	1196·1	0·3727	1·3798
600	1232·7	0·4108	1·4148
650	1277·9	0·4578	1·4565
700	1316·5	0·4980	1·4909
750	1351·3	0·5341	1·5201
800	1383·8	0·5678	1·5463
850	1414·5	0·5997	1·5702
900	1444·0	0·6304	1·5923
950	1472·3	0·6598	1·6129
P = 1,600 lb. per square inch.			
605·1°	1176·0	0·2635	1·3386
650	1235·6	0·3099	1·3933
700	1285·6	0·3488	1·4374
750	1327·1	0·3812	1·4724
800	1364·0	0·4099	1·5023
850	1397·9	0·4363	1·5287
900	1429·8	0·4611	1·5525
950	1460·8	0·4847	1·5745
1,000	1489·4	0·5076	1·5949
P = 2,000 lb. per square inch.			
636·5°	1149·8	0·1936	1·2985
650	1175·4	0·2099	1·3218
700	1246·6	0·2543	1·3847
750	1298·8	0·2869	1·4288
800	1342·0	0·3137	1·4638
850	1380·0	0·3374	1·4934
900	1415·0	0·3592	1·5194
950	1447·1	0·3793	1·5429
1,000	1478·4	0·3988	1·5645
P = 2,800 lb. per square inch.			
685·4°	1071·0	0·1029	1·2078
700	1114·9	0·1224	1·2476
750	1219·9	0·1691	1·3383
800	1287·0	0·1991	1·8906
850	1338·1	0·2218	1·4305
900	1381·4	0·2411	1·4628
950	1419·3	0·2580	1·4904
1,000	1454·6	0·2737	1·5149
P = 3,600 lb. per square inch.			
750	1067·1	0·0785	1·1953
800	1203·5	0·1254	1·3054
850	1282·8	0·1528	1·3673
900	1340·6	0·1729	1·4125
950	1387·3	0·1890	1·4445
1,000	1428·3	0·2033	1·4730

t	H	V	ϕ
P = 450 lb. per square inch.			
455·4°	1212·1	1·0419	1·4827
500	1243·7	1·1296	1·5166
550	1276·1	1·2192	1·5495
600	1306·5	1·3033	1·5789
650	1335·4	1·3836	1·6056
700	1363·4	1·4609	1·6302
750	1390·6	1·5361	1·6532
800	1417·2	1·6100	1·6748
850	1443·4	1·6825	1·6951
P = 600 lb. per square inch.			
485·4°	1212·0	0·7805	1·4559
500	1223·9	0·8055	1·4684
550	1260·8	0·8822	1·5059
600	1294·1	0·9513	1·5381
650	1325·2	1·0159	1·5667
700	1354·7	1·0773	1·5928
750	1383·2	1·1362	1·6168
800	1410·8	1·1937	1·6392
850	1437·8	1·2498	1·6602
P = 800 lb. per square inch.			
517·5°	1209·1	0·5804	1·4289
550	1237·7	0·6251	1·4558
600	1276·3	0·6851	1·4931
650	1310·8	0·7389	1·5249
700	1342·7	0·7887	1·5531
750	1373·0	0·8358	1·5786
800	1402·0	0·8811	1·6022
850	1430·2	0·9249	1·6240
900	1457·6	0·9677	1·6446
P = 1,000 lb. per square inch.			
544·1°	1203·4	0·4570	1·4021
550	1209·9	0·4649	1·4084
600	1256·1	0·5226	1·4532
650	1295·1	0·5712	1·4892
700	1330·0	0·6148	1·5200
750	1362·4	0·6551	1·5473
800	1393·0	0·6933	1·5721
850	1422·4	0·7299	1·5950
900	1450·8	0·7653	1·6163
P = 1,400 lb. per square inch.			
587·1°	1186·9	0·3111	1·3587
600	1204·2	0·3264	1·3751
650	1258·3	0·3746	1·4251
700	1301·8	0·4133	1·4635
750	1339·6	0·4470	1·4954
800	1374·1	0·4777	1·5233
850	1406·3	0·5063	1·5484
900	1436·9	0·5336	1·5713
950	1466·2	0·5597	1·5925
P = 1,800 lb. per square inch			
621·5°	1163·8	0·2255	1·3186
650	1208·6	0·2565	1·3595
700	1267·4	0·2972	1·4114
750	1313·6	0·3292	1·4529
800	1353·3	0·3567	1·4826
850	1389·1	0·3815	1·5105
900	1422·4	0·4046	1·5354
950	1453·6	0·4262	1·5681
1,000	1483·8	0·4471	1·5791
P = 2,400 per square inch.			
663·1°	1115·1	0·1433	1·2561
700	1193·8	0·1842	1·3253
750	1263·9	0·2206	1·3849
800	1316·8	0·2489	1·4274
850	1360·3	0·2703	1·4613
900	1398·8	0·2906	1·4900
950	1433·7	0·3087	1·5154
1,000	1466·7	0·3259	1·5383
P = 3,200 lb. per square inch.			
703·5°	1006·2	0·0645	1·1463
750	1158·7	0·1240	1·2769
800	1250·4	0·1597	1·3510
850	1312·8	0·1840	1·3997
900	1362·2	0·2032	1·4366
950	1404·0	0·2195	1·4670
1,000	1441·9	0·2343	1·4933
P = 4,000 lb. per square inch.			
800	1140·7	0·0931	1·2487
850	1246·4	0·1260	1·3316
900	1316·1	0·1477	1·3850
950	1369·0	0·1642	1·4223
1,000	1413·8	0·1782	1·4535

Note.—The first line under each pressure gives the values of H, V and ϕ for dry steam at the saturation temperature t_s

Recent Economic Changes[1]

An Analysis of Post-War Developments in American Economic Life

I—Characteristics of the Years 1922-1929

ACCELERATION rather than structural change is the key to an understanding of our recent economic developments. Gradually the fact emerged during the course of this survey that the distinctive character of the years from 1922 to 1929 owes less to fundamental change than to intensified activity.

Forty years ago David A. Wells wrote his "Recent Economic Changes," showing that the quarter-century which ended in 1889 was a period of "profound economic changes," which he described as "unquestionably more important and varied than during any former corresponding period of the World's history."

Each generation believes itself to be on the verge of a new economic era, an era of fundamental change, but the longer the committee deliberated, the more evident it became that the novelty of the period covered by the present survey rested chiefly in the fact that developments such as formerly affected our old industries have been recurring in our new industries. The changes have not been in structure but in speed and spread.

Invention is not a new art. Transportation and communication are not new services. The facilitating function of finance is older than coined currency. Agriculture is as ancient as history. Competition is not a new phenomenon. None of the changes in distribution on which emphasis has been laid in the last few years is basically new. Hand-to-mouth buying is old; sudden changes in style and demand are familiar; there is no new principle in instalment selling; cooperative marketing is no modern discovery; the chain-store movement dates back at least 25 years. But the breadth and scale and "tempo" of recent developments give them new importance.

The increased supply of power and its wider uses; the multiplication by man of his strength and skill through machinery, the expert division and arrangement of work in mines and factories, on the farms and in the trades, so that production per man-hour of effort has risen to new heights; the quickening of these instrumentalities through capital provided from the surplus incomes of a constantly widening proportion of our people—all these represent an accumulation of forces which have long been at work.

The committee, like other observers, was early impressed by the degree of economic activity in these seven years. It was struck by the outpouring of energy which piled up skyscrapers in scores of cities; knit the 48 states together with 20,000 miles of airways; moved each year over railways and waterways more than a billion and a half tons of freight; thronged the highways with 25,000,000 motor cars; carried electricity to 17,000,000 homes; sent each year 3,750,000 children to high school and more than 1,000,000 young men and women to college; and fed, clothed, housed, and amused the 120,000,000 persons who occupy our twentieth of the habitable area of the earth.

But while the period from 1922 to 1929 has been one of intense activity, the committee noted that this activity has been "spotty." Certain groups have been more active than other groups; certain industries busier than their neighbor industries, and certain geographical areas more prosperous than other areas.

While rayon manufacturers have worked at top speed, cotton mills have been on part time; while the silk-hosiery industry, the women's shoe trade, and the fur business have been active, there has been depression in the woolen and worsted industry; while dairying has been prosperous, grain growers have been depressed. Coal mining has been in difficulties, and classes of wholesalers and retailers have been under grave economic pressure. Progress has been made toward more stable employment in seasonal industries, yet "technological" unemployment, resulting from the displacement of workers by improved machinery and methods, has attracted attention.

Geographical differences also were noted. The Pacific States have made an extraordinary advance; the South has rapidly developed as a manufacturing area; the East North-Central Division has grown; while the New England States, and to some extent the Middle Atlantic section, have developed less rapidly and have experienced some difficulties in adapting their older industries to new conditions.

However, in spite of this variability, this difference in activity as between groups and areas and industries, the rising standard of living characteristic of this period was widespread and has reached the highest level in our national history.

Participation by the people as a whole in many of the benefits of increased productivity, which of itself varied as between different groups and geographical areas, has been one of the marked characteristics of the period. While industrial, agricultural, and commercial activity has been "spotty," the broad social advantages of our accelerated activity flowed out over the

As an outgrowth of the President's conference on unemployment of 1921, three national surveys have been set up to enlarge the general understanding of our economic system and to stimulate the continuing reduction of unemployment. The first of these surveys was the study of Business Cycles and Unemployment, made in 1922–1923 for a committee of the unemployment conference. The second was a study of Seasonal Operation in the Construction Industries, made in 1923–1924 for another committee of the conference.

The survey of Recent Economic Changes, begun in January, 1928, and completed in February, 1929, is an analysis of post-war developments in American economic life, particularly those since the recovery from the depression of 1920–1921.

The committee charged with the survey was directed to make a critical appraisal of the factors of stability and instability; in other words, to observe and to describe the American economy as a whole, suggesting rather than developing recommendations.

The basic investigations were made under the auspices of the National Bureau of Economic Research (Inc.), with the assistance of an unprecedented number of governmental and private agencies. While the national bureau is solely responsible for the basic survey, the committee is solely responsible for the interpretation of the facts set out in the brief report on this and the following pages.

[1] Report of the Committee on Recent Economic Changes of the President's Conference on Unemployment. The full report is published by the McGraw-Hill Book Co., New York, N. Y. See also p. 535.

land. For example, the highway-building programs throughout the nation were not limited to the intensely active areas; good roads were extended in all directions, serving the whole population. The same might be said for educational advantages, radio entertainment, personal mobility made possible by low-priced motor cars, swift and dependable transportation and communication, and numerous other facilities and services making for comfort and well-being, beyond the elemental requirements of food, clothing, and shelter.

This spread of higher living standards has been characteristic of our national life practically throughout our history. As a phenomenon it is not new, but in its degree and scope it has taken on a new importance.

The Speed Which Power Has Added to Production

Characteristic also has been the rise in the use of power—three and three-quarters times faster than the growth in population—and the extent to which power has been made readily available not alone for driving tools of increasing size and capacity, but for a convenient diversity of purposes in the smallest business enterprise and on the farm and in the home.

Factories no longer need cluster about the sources of power. Widespread interconnection between power plants, arising out of an increasing appreciation of the value of flexibility in power, and made possible by technical advances during recent years, has created huge reservoirs of power so that abnormal conditions in one locality need not stop the wheels of industry.

The increasing flexibility with which electricity can be delivered for power has enabled manufacturers and farmers to meet high labor costs by the application of power-driven specialized machines; and power in this flexible form has penetrated into every section of the United States, including many rural areas. The survey shows that as a nation we now use as much electrical energy as all the rest of the world combined.

Through the subdivision of power the unskilled worker has become a skilled operator, multiplying his effectiveness with specialized automatic machinery and processes. Thus the unit cost of production has been reduced, the drudgery eliminated from much unskilled work, and wages maintained or actually increased.

The Spread in the Source and Use of Credit

This acceleration of forces and its resultant rising standard of living have been facilitated by a continuing supply of funds.

In the breadth of the sources from which capital and credit have been available and in the quickening method of their use may be observed again the changes in speed and spread of our recent economic activity.

In former periods the savings funds of the American people were not alone adequate for our capital requirements. In periods of business expansion the demand for funds pressed heavily upon the supply.

The reverse has been found to be true in the period under review. For the larger part of this period not only the earnings and savings of the people supplied the additional capital for financing the rapid development of industry, but in addition they furnished several billions of dollars for loans to foreign countries.

Stimulated by the urge for funds to finance the vast production program of the United States during the World War, the number of shareholders in the country's business enterprises has, it is estimated, grown from about two million to more than seventeen million; and out of increasing incomes these investors have continued to pour their savings into the stream of credit.

During the later months of the period covered by the survey a new tendency has been observed. Investors, as well as a large body of speculators, have invested through the stock exchanges not only their savings but the proceeds of loans secured through banks and brokers, until the credit structure of the country has been sufficiently weighted to indicate a credit stringency, resulting in an abnormally high rate for call money and an appreciable increase in the rate of interest for business purposes. The consequences of this process cannot be measured at this time, but they are factors in the problem of maintaining economic balance which will be touched on later in this report.

Meanwhile industry has been able to reduce its requirements for short-term credits from the banks through issuance of securities. The preference for permanent methods of financing business is reflected in the relatively small increase in commercial loans of banks in recent years, as contrasted with the increase in security holdings and collateral loans.

Imports of gold early in the period covered by the survey which tended to make credit easier; the growth of savings in spite of increased spending; the popular confidence in the financial structure, especially in the Federal reserve system, and the power of the system to move available credit to the places where it is needed, mark a great advance during these seven years.

There has also been an increase in the velocity of the turnover of credit, due to improved transportation and communication, scientific control of inventories, the continuation of the simplification movement, and our accelerated turnover of commodities. Business has thus developed a new degree of economy in the use of credit, which may be set down as another characteristic of the period.

II—Price Relationships, Wages, and Cost of Living

THE period under review is perhaps too brief for a definite judgment, and we are as yet too close in point of time to get an accurate perspective, but the committee feels that in the field of price relationships, wages, and the cost of living is to be found one of the striking and significant developments revealed by the survey, and one which more than any other gives these years their distinctive character.

Contrasting two periods of our comparatively recent economic history will perhaps serve to make clear the significance of these factors.

According to the best available statistics, in the period between 1896 and 1913, the wholesale price level rose on the average 2.3 per cent a year, but wages rose only a little more, so that their purchasing power advanced only 0.5 per cent a year. In the period from 1922 to 1927 prices declined on the average 0.1 per cent per year, while the purchasing power of wages rose 2.1 per cent a year.

In this latter period the fortunate synchronizing of a high wage level and a stationary cost of living created a phenomenon, new in degree, which had widespread influence on the economic situation and which will bear close study in its details.

Relative Price Stability

The increasing tendency toward price stability, both as between classes of commodities and in the price experience of individual commodities, was a characteristic of the period under review, tending toward a more equitable basis of exchange of products among the various groups. Price fluctuations seem to have been held within narrow limits during this period by a combination of factors: A more complete background of statistical information making possible better judgment regarding supply and demand on the part both of producers and consumers, prudence on the part of management, cost reductions by technicians, skill on the part of bankers, an enlightened attitude on the part of labor, and the expansion of foreign markets.

Relative price stability has involved a change in the direction in which business men look for profits. Profits made from the fluctuations of individual commodity prices and from changes in the relation among prices have tended to diminish.

Whether the price relationships of recent years prove to be transitory or permanent, they represent today a huge gain which is reflected in all parts of the economic organism. It is a development too new to permit of dogmatic interpretation, but the committee believes that this decreasing variability in prices at a time when the productivity per hour of labor has been greatly increased and the demand for goods has been greatly stimulated is one of the most significant factors disclosed by the survey.

The widening gap between wages and the cost of living—wages increasing while the cost of living was stationary—may be assumed to have contributed definitely to the degree of prosperity which has characterized the period as a whole. With rising wages and relatively stable prices we have become consumers of what we produce to an extent never before realized.

The factors in this situation appear in part to be accidental and in part the consequences of an advanced economic point of view.

In the early post-war period much of the press and many employers demanded a "liquidation" of labor. It was freely declared that business could not settle down until wages were brought back to pre-war levels. Labor had enjoyed a higher standard of living and naturally opposed wage cuts.

This might have precipitated a period of serious strife had it not been that leaders of industrial thought, watching the trend of affairs, noted that the result of the continuance of high wages was that the dammed-up purchasing desires which had been held back during the war on account of the national economic program burst forth, and not only the high wages which were being currently earned but accumulated savings as well were poured into the channels of commerce.

They were quick to grasp the significance of the power of the consumer with money to spend to create an accelerated cycle of productivity.

They began consciously to propound the principle of high wages and low costs as a policy of enlightened industrial practice. This principle has since attracted the attention of economists all over the world, and while it is in no sense new, its application on a broad scale is so novel as to impress the committee as being a fundamental development.

Production Increase and the Expansion of Human Wants

Partly as a result of this newly sensed principle of an accelerated cycle of production-consumption, and partly by reason of the development of a stream of credit and an abundance of flexible power made broadly available, the years 1922 to 1929 witnessed a marked increase in the physical volume of production. Some years stand out more conspicuously than others; two—1924 and 1927—show minor recessions; but the period as a whole has been notably consistent.

Since 1922 primary production has been increasing 2.5 per cent a year; manufacturing, 4 per cent a year; transportation, 4 per cent. Taking 1919—a year of fair harvests—as a base, crop production in 1922 was 102; in 1925, 104; in 1927, 106.

There have been prosperous periods in the past which may have surpassed these rates of increase, but none so far as the committee can learn which has shown such a striking increase in productivity per man-hour. Notwithstanding the reductions in hours of labor, per capita productivity is nearly 60 per cent greater than it was toward the close of the nineteenth century; the increase in per capita productivity in manufacturing from 1922 to 1925 was 35 per cent; the productivity of farm workers has increased at a rate probably never before equaled.

And these increases in productivity have been joined to a corresponding increase in the consuming power of the American people. Here has been demonstrated on a grand scale the expansibility of human wants and desires.

Economists have long declared that consumption, the satisfaction of wants, would expand with little evidence of satiation if we could so adjust our economic processes as to make dormant demands effective. Such an expansion has been going on since the beginning of the industrial revolution. It is not a phenomenon of the postwar period, except in degree. But it is this degree of economic activity, this almost insatiable appetite for goods and services, this abounding production of all things which almost any man can want, which is so striking a characteristic of the period covered by the survey.

Optional Consumption

The committee finds, from a study of the fact-finding survey on which this report is based, that as a people we have become steadily less concerned about the primary needs—food, clothing, and shelter. We have long since lost all fear concerning our food supply, and so we no longer look on food as a luxury or as a primary source of pleasure. American food standards have risen, but we hear little of the "high cost of living," and the slogan of the "full dinner pail" is obsolete. We wear less clothing; more rayon and silks, less cotton and wool. Our wants have ranged more widely and we now demand a broad list of goods and services which come under the category of "optional purchases."

The rapidly increasing number of families in the United States having a considerable margin of earnings available for "optional consumption"—optional in the sense that this portion of the income may be saved or spent, and if spent the manner of its spending may be determined by the tastes of the consumer or the nature of the appeals made to him by the industries competing for his patronage—presents one of the marked characteristics of the recent economic situation. It is the personal or individual expression of the gap between rising wages and the relatively stable cost of living, referred to at the beginning of the present section.

Consumption and Leisure

Closely related to the increased rate of production-consumption of products is the consumption of leisure.

It was during the period covered by the survey that the conception of leisure as "consumable" began to be realized upon in business in a practical way and on a broad scale. It began to be recognized, not only that leisure is "consumable," but that people cannot "consume" leisure without consuming goods and services, and that leisure which results from an increasing man-hour productivity helps to create new needs and new and broader markets.

The increasing interest in the fine arts and in science; the increased sales of books and magazines; the increase in foreign travel; the growing interest and participation in sports of all kinds; the domestic pilgrimages of some 40,000,000 motor tourists who use more than 2000 tourist camps; the greatly increased enrolment in our high schools and colleges; the motion-picture theaters and the radio—all these reflect the uses of increasing leisure.

During the period covered by the survey the trend toward increased leisure received a considerable impetus. The work week was shortened in the factory by better planning and modern machinery, and the work day was shortened in the home by the increased use of time- and labor-saving appliances and services.

Few of the current economic developments have made such

widespread changes in our national life or promise so much for the future as the utilization of our increasing leisure.

"Mass Services"

The service functions are not new, but few of the developments revealed by the survey are of greater potential significance than the accelerated growth of our service industries—travel, entertainment, education, insurance, communication; the facilities of hotels, restaurants, delicatessen stores, steam laundries, and public libraries, to mention but a few.

An evolution which has been going on for centuries has only recently been revealed as a mass movement. We now apply to many kinds of services the philosophy of large-scale production. We have integrated these services and organized them, and we have developed the new philosophy to such a degree in recent years that we now have what might be termed "mass services." These have helped to create a new standard of comfortable living in the United States, and have afforded employment for millions of workers crowded out of agriculture and the extractive and fabricating industries.

It was, in fact, the timely development of "mass services" which saved our country from a critical unemployment problem during recent years.

No serious cyclical fluctuations have characterized the period under review, so that the unemployment due to the business cycle has not been marked; but it has become evident that unemployment can arise as a result of industrial efficiency as well as of inefficiency. In the latter case we have seasonal or intermittent unemployment; in the former case what has come to be known as "technological" unemployment resulting from the introduction of new machinery and processes. The survey seems to indicate that the time has come to devote continuing attention not only to the problems of cyclical unemployment but also to this newer problem of "technological" unemployment if we are to forestall hardship and uncertainty in the lives of the workers.

Where progress may be working an advantage to the people as a whole, it inevitably works temporary hardship upon certain classes—those skilled workers in a trade, for example, whose work is taken over by machines. This is a serious aspect of the problem of unemployment. It involves, in many instances, learning new trades, and, in most instances, the loss of time in securing other jobs. Yet from a broad social point of view, while it works hardship on those workers displaced by the introduction of machinery or improved processes, the social gain is real and permanent.

Such economic transformations are not so much changes as readjustments due to the progressive needs of modern society and to the necessity of taking advantage of the modern developments in science. They have arisen in agriculture as well as manufacturing and transportation, and they have affected employers as well as employees. There is nothing new about these problems; the accelerated rate of readjustment is what has recently engaged the attention of wage earners and management.

As has already been intimated, the acceleration of technological shifts in production and consumption would have resulted in much more serious unemployment if workers had not been absorbed in the newly expanded service industries which both create and serve leisure.

Our Natural Advantages

It is obvious, of course, that the economic position of this nation is in no slight degree due to our possession of abundant raw materials and sources of power, to the fact that our domestic market is so large, and that there are no trade barriers between the states of our Union. We can exchange goods without stopping them for inspection or the payment of duties between states. We can effect their transfer without the barriers of differing languages or customs. Advertising is peculiarly effective because we have so great an area with a common language which enables us to talk to all the people and to develop national consumption habits, which in turn make possible large-scale production.

This fortuitous situation should be borne in mind as an important factor in both the speed and the spread which have characterized our recent economic development.

The balance which has been maintained between consumption and production is nowhere better shown than in the fact that wages have been rising, and that there has been no striking increase of unemployment in a period marked by the broadest technological advancement which we have yet known.

Perhaps the deepest economic significance of the new situation lies, not in the rapidity with which the service industries have grown and have become integrated, nor in the universality of their spread, but in the fact that the situation which they have created is reciprocal. Our increasing standard of living is not participated in only by those who produce our food, clothing, and shelter, but has flowed back to those in the service industries. The population as a whole can enjoy the rising standard of living—the music which comes in over the radio—the press, the automobile and good roads, the schools, the colleges, parks, playgrounds, and the myriad other facilities for comfortable existence and cultural development.

Our ancestors came to these shores with few tools and little organization to fight nature for a livelihood. Their descendants have developed a new and peculiarly American type of civilization in which services have come to rank with other forms of production as a major economic factor.

Remote Saturation Points

The survey has proved conclusively what has long been held theoretically to be true, that wants are almost insatiable; that one want satisfied makes way for another. The conclusion is that economically we have a boundless field before us; that there are new wants which will make way endlessly for newer wants, as fast as they are satisfied.

We have the power to produce and the capital to bring about exchange between the producing and consuming groups. We have communication to speed and spread the influence of ideas. We have swift and dependable transportation. We have an educational system which is steadily raising standards and improving tastes. We have the sciences and arts to help us. We have a great national opportunity.

Important as is the development of the economic side of our national life, through invention and discovery of new industries and new callings, an illustration of the potentialities of further lifting the national standard of living, without developing another invention or discovery and without creating a new want, can be drawn from a single industry—that of electrical appliances.

A home or farm wired for electricity is a different economic unit from one which is not wired. Each such home, whether in city or country, can take advantage of electricity for lighting, and on the farm an automatic water-supply system makes available water at convenient spots for domestic and farm uses.

A survey of city and village homes indicates the use of electricity for many additional applications of highly specialized devices. In 1928 apparently a large percentage of the homes wired for electricity had electric flatirons; less than one-third of them had washing machines; slightly over one-third of them had vacuum cleaners; less than 5 per cent had electrical refrigerators. We are far from the saturation point in connection with any of these devices.

To take one other example, there is perhaps no more dramatic illustration of a rising standard of living than the growth and development of radio in recent years. This newest application of electricity has found its way into millions of homes. On January 1, 1928, there were 7,500,000 sets in use. Yet about 70 per cent of American homes are still without the radio.

We seem only to have touched the fringe of our potentialities.

III—Economic Balance

MANY influences have been at work during the period covered by the survey welding the people of the United States into a new solidarity of thought and action. The telephone and telegraph, the automobile, the radio, and the railroads form lines of communication which have brought together East and West, South and North.

Other and less tangible influences reaching further into the past, but accelerated and strengthened by the experiences of the World War, have also contributed to our solidarity. Economic reorganization; the cooperation of business leaders, economic experts, and the Government; the general spread of information; the growth of trade associations; the cooperation of labor to increase productivity; the restriction of immigration—all of these have grown in importance in peace after their stimulation by the war.

Making for solidarity has been popular education which has increased amazingly. We are spending $2,500,000,000 each year on public and private education—an increase of 250 per cent in a decade. Expenditures for free college and university education have increased nearly 350 per cent in little more than 10 years.

And there is another factor which has contributed to the welding process, and to the economic advancement of the nation: The broadening influence of America's creative minds—the minds of the leaders in Government and in education, in research, in management and in labor, in the press, and in the professions. To their influence we have come to look in large measure for the maintenance of our economic balance.

While ours has been a period of great economic activity and industrial productivity, and of a degree of economic stability which must be rated as high when we consider the readjustments in every department of economic life made necessary by the post-war crisis and by the transition from war economy to peace economy; and while America has a promising future, the outstanding fact which is illuminated by this survey is that we cannot maintain our economic advantage, or hope fully to realize on our economic future, unless we consciously accept the principle of equilibrium and apply it skilfully in every economic relation.

The forces that bear upon our economic relationships have always been sensitive. All parts of our economic structure, from the prime processes of making and of marketing to the facilitating functions of finance, are and have been interdependent and easily affected. And therein lies the danger: That through ignorance of economic principles, or through selfish greed, or inadequate leadership, the steady balance will be disturbed, to our economic detriment.

If natural resources, especially the land, are wastefully used; if money in quantity is taken out of production and employed for speculation; if any group develops a method of artificial price advancement which puts one commodity out of balance with other commodities; if either management or labor disregards the common interest—to this extent equilibrium will be destroyed, and destroyed for all.

To maintain the dynamic equilibrium of recent years is, indeed, a problem of leadership which more and more demands deliberate public attention and control. Research and study, the orderly classification of knowledge, joined to increasing skill, well may make complete control of the economic system a possibility. The problems are many and difficult, but the degree of progress in recent years inspires us with high hopes.

In the marked balance of consumption and production, for example, the control of the economic organism is increasingly evident. With the development of a stream of credit to facilitate business operations, and with flexible power to energize industry and to increase the effectiveness of the workers has come an increasing evenness in the flow of production. Once an intermittent starting and stopping of production-consumption was characteristic of the economic situation. It was jerky and unpredictable, and overproduction was followed by a pause for consumption to catch up. For the seven years under survey, a more marked balance of production-consumption is evident.

With greater knowledge of consuming habits, with more accurate records of the goods consumed, a sensitive contact has been established between the factors of production and consumption which formerly were so often out of balance.

Where pools of goods once were accumulated by the manufacturer, the wholesaler, the jobber, and the retailer; where high inventories once meant distress, shutdowns, failures, and unemployment whenever the demand subsided, there is now a more even flow from producer to consumer.

Increasing skill and scientific data have made the anticipation of demand far more accurate, and by accurate anticipation the deliberate balance between production and consumption has in a measure been maintained. By advertising and other promotional devices, by scientific fact finding, by a carefully predeveloped consumption, a measurable pull on production has been created which releases capital otherwise tied up in immobile goods and furthers the organic balance of economic forces. In many cases the rate of production-consumption seems to be fairly well under control.

To maintain this balance, and to extend it into fields which are not now in balance with the more prosperous elements of the nation, is clearly an important problem of leadership. With certain natural resources still wastefully exploited, with great industries such as agriculture and coal mining still below the general level of prosperity, with certain regions retarded, there remains much to do. To bring these more fully into the stream of successful economic forces is a problem of the first order.

Our complex and intricate economic machine can produce, but to keep it producing continuously it must be maintained in balance. During the past few years equilibrium has been fairly well maintained. We have not wasted the hours of labor by strikes or lockouts. Until recently we have not diverted savings from productive business to speculation. There has been balance between the economic forces—not perfect balance, but a degree of balance which has enabled the intricate machine to produce and to serve our people.

As long as the appetite for goods and services is practically insatiable, as it appears to be, and as long as productivity can be consistently increased, it would seem that we can go on with increasing activity. But we can do this only if we develop a technique of balance. Toward such a technique the committee believes the skilful work of the economists, engineers, and statisticians who prepared the survey on which we have based the facts and interpretations expressed in this brief report, will contribute. Our effort has been to suggest a pattern by which their work may be appraised; to set up an orderly plan by which the facts may be articulated and against which later and better information may be more accurately judged. We recommend a study of the fact-finding survey as a whole to all who are faced with the problems of business administration and public leadership.

Informed leadership is vital to the maintenance of equilibrium. It depends upon a general knowledge of the relations of the parts each to the other. Through incessant observation and adjustment of our economy, we can learn to maintain the economic balance.

Underlying recent developments is an attitude of mind which seems to be characteristically American. Our nation is accustomed to rapid movement, to quick shifts in status; it is receptive to new ideas, ingenious in devices, adaptable. Our economy is in large measure the embodiment of those who have made it.

Our situation is fortunate, our momentum is remarkable. Yet the organic balance of our economic structure can be maintained only by hard, persistent, intelligent effort; by consideration and sympathy; by mutual confidence, and by a disposition in the several human parts to work in harmony together.

HERBERT HOOVER[2]	ADOLPH C. MILLER
WALTER F. BROWN	LEWIS E. PIERSON
RENICK W. DUNLAP	JOHN J. RASKOB
WILLIAM GREEN	ARCH W. SHAW[3]
JULIUS KLEIN	LOUIS J. TABER
JOHN S. LAWRENCE	DANIEL WILLARD
MAX MASON	CLARENCE M. WOODLEY
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The International Management Institute and Its Work

BY HENRY S. DENNISON,[1] FRAMINGHAM, MASS.

THREE general ideas influenced the founding of the International Management Institute in Geneva. First was the belief that every spreading of the practices and principles of good management in this modern, complex world is essentially worth while. Second, there was the doctrine that wherever better management results in lower prices and higher wages, that is to say, in rising living standards, a strong force is exerted toward social stability and the solid progress that can go with it. Third, there was the faith that besides the influence toward world peace which social stability exerts, the chances of world peace increase directly with increase in the fullness and variety of the international contacts which are held during peace times and for peaceful purposes.

Opportunity offered about four years ago when some men from the International Labour Office in Geneva, the officers of the International Committee on Scientific Management, which had been formed as a result of the Prague Congress, and Mr. E. A. Filene, all found themselves in accord as to the need of such an institute, although each had reached that conclusion from a different starting point. The interest of the Committee was that of men proud of their profession and anxious to lift it to higher standards. The men of the Labour Office had been working to prevent the aftermath of war from reducing the status of the workers below that of civilized men; they had come to believe that progress in living standards of the worker and even reasonable security that his present standards could be held depend heavily upon an increase in his producing power made possible by good management. The interest of the American was in the enhancement of the chances for peace which come from social stability.

Out of their conference grew the plan to place in Geneva an institution which should serve, as so many associations in America have done, as an active, energetic agency to increase the exchange and discussion among business men of information about best current management practices.

ORGANIZATION OF THE INSTITUTE

The Institute was organized as an independent organization, affording representation upon its Board of Management to the three founder members and to other interested parties. Its early finances were guaranteed in order that it might have a chance to prove by its works that its support was worth while to European business. American participation has not been at all with the idea that America had methods of management which should be imposed upon Europe, but rather that the good of the whole business world demanded the widest possible spread of good management practices. It has turned out, as was expected, that European management has much to teach as well as to learn, and that American participation can be counted to the direct as well as to the indirect advantage of American business.

The Institute was barely organized before it was called upon by the Economic Conference of 1927 to assist in the discussions on rationalization, including consideration both of scientific management and of mergers. Through this and other publicity the knowledge of just what scientific management is and what may be expected of it has increased tremendously in Europe, and the interest in its practical application has risen to a high point. The Institute has since then directly instigated a great deal of activity in the study and promotion of management methods in a variety of European countries. It has promoted the foundation of permanent groups of industrialists along the lines first laid down by the Retail Research Association of New York and the Manufacturers Research Association of Boston. These are small associations, providing for intimate exchange of experience and of practical assistance. There are today seven such associations in Great Britain, five in Switzerland, and one in Austria; there has been an international group of department stores recently organized in Paris, and groups in Belgium and Holland are now experimenting with this sort of mutual organization.

THE INSTITUTE A CLEARING HOUSE FOR MANAGEMENT LITERATURE OF WORLD

Within its offices the Institute acts as a clearing house for the management literature of the world and is handling a rapidly increasing number of specific inquiries as to where information can be had on one or another practical subject. The Bulletin of the Institute is published in three languages, English, German, and French. For its material nearly six hundred periodicals in more than a dozen languages, which reach the Institute every month, are studied.

[1] President, Dennison Manufacturing Company.

[2] Chairman.

[3] Acting Chairman in later deliberations when the Chairman was unable to take part.

[4] Secretary.

In most European countries, moreover, there have been formed within the last few years national associations for the advancement of the art of management. These the Institute has cooperated closely with and has helped bring them into touch with each other, thus aiding to prevent the development of a separatist attitude.

The Institute has cooperative relations with the International Labour Office, calling for help from its research division, giving help in its turn, and keeping up especially close relations with the newly organized industrial relations section of the Labour Office.

SPECIAL ACTIVITIES OF THE INSTITUTE

Some of the special work of the Institute in which it is now or soon is to be engaged includes an international study of certain problems of railroad management. Three reports are being drawn up by European railroad men in cooperation with each other, one upon problems of material, another upon traffic problems, and a third upon problems of administration in railroads. There is being instituted also a study of scientific management within banks and another study of management standards as affecting credit. A special and very difficult study has been begun into the peculiar administrative and management problems which face combines of separate companies, a subject which is of immediate and vital importance but upon which information is scattered and contradictory. The Institute is to make a special effort to set forth in practical fashion a study of scientific management in small factories, for the dramatic force of the economies which have been made possible by large-scale production has tended in Europe to give the notion that scientific management can exist only in the largest plants. A collection of the extraordinary results which have been gained by some of the smallest factories will do much to put a fresh spur and fresh courage into the hearts of those whose business cannot admit of mass production.

The Institute plans also to translate a few carefully selected books into the three principal languages, books which it believes will have sale enough to pay for translation but which publishers cannot feel themselves warranted in taking on.

A very sound beginning has been made during the past two years. Undoubtedly progress has been slowed up somewhat by the difficulties arising from differences in language and national habits of mind, but these difficulties are greatest at the beginning and become less and less as national units become organized and as the basic ideas of sound management become more and more thoroughly and broadly understood. It is the belief of those working for the Institute that the efforts to meet these very difficulties are in themselves of value because they constitute one more international activity which, in the long run, and in the aggregate, may make for a sound international understanding. The Institute's work is, in any case, doing a worthy bit toward raising the intellectual and ethical standards of management up to those of the great professions, and toward that soundest measure of social progress, a rising general standard of living.

The Need for More Statistical Data[1]

THE complexity of American economic activities and the rapid changes in them call for more statistical data. Without attempting exhaustive enumeration, the more conspicuous gaps and deficiencies may be briefly mentioned.

Little statistical material is now collected regarding several important branches of economic activity, particularly those which render services. The recent shift of workers from farms and factories into the service fields makes statistical data concerning those fields particularly essential at this time. To that end the classification and analysis of the statistics of occupations of the census of 1930 should be given special attention. A census of distribution is another major need. Data should also be obtained regarding the construction industry, automobile repair shops, hotels and restaurants, and similar enterprises, and establishments providing recreation, instruction, and amusement.

There is need of more complete statistical information regarding labor. In addition to more adequate occupation statistics, current, annual, and monthly returns of employment and payrolls should be extended to the major fields of activity not now covered. Wage and earning statistics should be more comprehensive, and in addition to averages the number of workers should be classified according to the amounts received. Similar information is needed concerning hours of labor.

Although improvement has recently been made in price statistics further expansion and more thorough analysis are desirable. The great and growing importance of elaborate, often non-standardized, commodities makes it difficult to compute general price indexes which correctly measure changes in the buying power of money. The most pressing immediate need is for a revision of the indexes of cost of living as a means of interpreting changes in the buying power of money wages and other incomes. There is call also for more complete analysis of the price levels of groups of commodities based on a number of different principles of classification, as well as for more detailed statistics of the prices of individual articles.

We need more statistical information regarding the values, gross and net, of the products and services of different branches of industry, both as a basis for ascertaining aggregate national income and as a means of comparing the productivity of different branches and determining the trends in them. In the census of manufactures it would be useful to distinguish the cost of raw materials furnished by non-manufacturing industries from the cost of semi-manufactured goods supplied by other factories; among other advantages this would facilitate comparisons between production and export of manufactures.

As regards many classes of statistics greater accuracy and representativeness should be sought. Statistical series are often based on the principle of sampling and the samples are not always truly representative. There is reason to believe, for example, that most series relating to employment and amount of payroll and some relating to production have a downward bias due to inadequate covering of new plants.

Even where the original statistical data are adequate the analysis of them is often unsatisfactory and comparisons with other series difficult or impossible. For example, index numbers are computed with reference to different base periods, and averages for groups of years are made up for incomparable periods of time. Certain monthly series are adjusted for variations in the length of the month or for seasonal factors, while such adjustment is not made for other series. Commodities and groups of commodities, industries and groups of industries, are differently defined by the several statistical authorities. Standardization and coordination of methods of analysis would add greatly to the value of economic statistics and will become still more essential as their scope is further expanded.

[1] From an addendum to Report of Committee in Recent Economic Changes published on pp. 529–534 ante.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Handley Page Interceptor-Plate Control of Slot

THE functions of the Handley Page automatic slot are well known. In short, the fitting of the automatic slot to a wing allows that wing to go on lifting, even when the airplane is flying in what would otherwise be a stalled attitude. Although the opening of the slot causes the wing to go on lifting and so causes the ailerons to continue to be effective, ordinary ailerons still become "soggy" at the stall.

For certain types of aircraft an exceptionally powerful control is desirable at and beyond the stall. Service aircraft, for example, are required to have all-round maneuverability, and even while turning at very high angles of incidence they need the greatest powers of control with which they can be furnished.

For these aircraft a new type of control, known as the interceptor plate, has been developed by Handley Page Ltd. for use in conjunction with the automatic slot. This device consists of a small plate normally hidden inside a recess in the wing, parallel and close to the front spar.

When the aileron on one side is pulled up, a link mechanism causes the interceptor plate to rise vertically from its recess and so deflect upward the air flow through the slot over the plane. In this way the whole effect of the slot is destroyed, resulting in the stalling of the wing with consequent loss of lift and increase in resistance.

As an example let us assume that an airplane fitted with automatic slots is stalled with slots wide open and that owing to a wind gust the left wing drops. The ordinary automatic slot would enable the pilot to use his lateral control. By pulling his control column across to the right the pilot would depress his left aileron and raise the right, ruddering at the same time to prevent a tendency to turn to the left.

When, however, the interceptor was fitted, the raising of the aileron on the right wing would cause the interceptor to appear as a vertical plate along the right wing tip, effectively killing the lift and greatly adding to the resistance of that portion of the wing. This increase in resistance would offset that due to the pulling down of the left-wing aileron, so that much less or practically no rudder would be required.

The result would be that the low left wing would be raised by pulling down the aileron and the right wing would be depressed by killing its lift.

A long series of full-scale tests in the air on a machine so fitted has fully borne out the experiments with models, and the fact has been proved that with this device the control is no different in feel from the ordinary aileron and is no heavier to operate. (*The Aeroplane*, vol. 36, no. 8, Feb. 20, 1929, p. 272, *d*)

Characteristics of an Autogyro

THIS is a summary of experimental and theoretical investigations based on work with the autogyro in Great Britain.

In general it may be stated that the performance of a gyroplane, as revealed by these two series of flight tests, is comparable with that which would be predicted by the application of theory, and that this performance is inferior to that of the corresponding airplane of the same weight and horsepower as regards speed, rate of climb, and distance to take off. The gyroplane is able to land more slowly and to pull up more quickly after landing, and, in contrast to an airplane of conventional design, remains stable at large angles of incidence. The only point which remains uncertain is the capacity of a gyroplane to descend vertically at a low speed, but the practical importance of this question should not be exaggerated since the actual gliding descent at an inclination of 30 deg. to the horizontal would imply the possibility of vertical descent whenever the wind speed exceeded 20 m.p.h. The rate of rotation of the windmill was observed to increase slowly with the forward speed of the aircraft, but no precise measurements were obtained.

The outstanding merit of the gyroplane is its high maximum-lift coefficient, the value of which is estimated by the theory to be 0.56 on disk area or 2.8 on blade area for the comparatively high solidity ratio of 0.2, while the observed velocity in a glide suggests rather higher values. Moreover, there is no loss of stability such as occurs when an airplane stalls, and a gyroplane remains completely stable at all angles of incidence. A gyroplane designed to give a moderate rate of vertical descent should therefore have a degree of safety unattainable by an airplane even with automatic slots. On the other hand, it should be possible by the use of slots and flaps to construct an airplane whose landing speed would be nearly as low as that of a type of gyroplane.

According to the model tests the forward speed of a gyroplane, corresponding to the maximum lift-drag ratio of the windmill, is at least four times the stalling speed, while for a typical airplane the corresponding speed ratio is less than two. On the other hand the maximum observed lift-drag ratio of the windmill is $7^1/_2$, i.e., less than half that of a typical airplane wing system. If a gyroplane could be designed with a top speed of four times its stalling speed, it would appear that the windmill of the gyroplane would be as efficient at top speed as the wings of a biplane with the same stalling speed, but at lower speeds the gyroplane becomes progressively less efficient since its lift-drag ratio decreases while that of the airplane increases at first. The fundamental reason for this loss of efficiency of a gyroplane has been explained by Professor Bairstow as being due to the progressively greater distance traveled by the blade elements. It follows also that the rate of climb of a gyroplane will always be less than that of the corresponding airplane. (H. Glauert and C. N. H. Lock, Aeronautical Research Committee (British) Memoranda no. 1111; abstracted through *Aviation Engineering*, vol. 2, no. 5, May, 1929, pp. 9–10, 2 figs., *e*)

Chemical Cooling of Aircraft Motors

IN THIS case the cooling liquid is ethylene glycol. It is a clear colorless, odorless fluid boiling at 387 deg. fahr. In structure and characteristics it resembles ethyl alcohol and glycerol, and occupies an intermediate position between the two. It is not a newly discovered liquid and has been on the market for a considerable time. It is claimed that its use in connection with high-temperature cooling is a new development. When substituted for water in the jackets and radiators of an engine it can be operated at outlet temperatures of 300 deg. fahr. instead of the usual 180 deg., permitting the use of a radiator of about one-quarter the size now required.

A much smaller radiator can be used because of the higher temperature difference.

The ordinary radiator used in a modern pursuit plane, for example, weighs 66.5 lb. and its cooling water 112.5 lb., or a total of 179 lb. The radiator often represents as much as 20 per cent of the total resistance of the airplane.

By replacing it with one of 25 per cent capacity and filled with ethylene glycol the results attained are surprising. The radiator resistance is cut to a fraction of its former value, 100 lb. are saved in weight and the speed of the airplane is increased by 11 m.p.h. By using small wing-skin radiators in place of the new one-fourth-size radiator the speed is increased 15 m.p.h. above that of the standard pursuit plane with the present conventional radiator. Such a reduction of necessary cooling area may make practicable the use of wing-skin radiators used formerly on racing airplanes only. (*Aviation Engineering*, vol. 2, no. 5, May, 1929, p. 14, *g*)

AIR ENGINEERING

Discharge Coefficients of Square-Edged Orifices for Measuring the Flow of Air

THE purpose of this investigation was to obtain experimental data from orifices of various sizes and proportions, working over a wide range of static pressures and rates of flow, so as to get as much systematic general information regarding the properties and behavior of such orifices as was practicable with the facilities and in the time at the authors' disposal.

In regard to any one orifice, the object of the experiments is to determine the relation between the rate of discharge of air through the orifice, on the one hand, and the temperature and static pressure of the air and the pressure drop or differential across the orifice, on the other. If this relation has been determined and expressed in simple form, the rate of discharge may thereafter be found, by computation or graphically, from observations of the temperature, static pressure, and differential, and the orifice may thus be utilized as a flow meter for air.

The principle of the experiments is very simple: A steady stream of compressed air is sent along the pipe in which the orifice to be tested is installed; the temperature, static pressure, and differential are observed by means of instruments near the orifice; and at the same time the rate at which air is flowing along the pipe and through the orifice is measured by some independent means, either ahead of the orifice or farther along the line.

The orifices used were of familiar types—round, concentric with the pipe, and square edged at the upstream face of the planes. Both plates made at the Bureau of Standards and plates loaned from outside were used.

The Bureau plates were made with great care, and the inclusion of the commercial plates increased the interest of the results by showing that, as a general rule, the behavior of the commercial plates did not differ appreciably from that of similar plates made at the Bureau.

The plates were all in good condition, with the corner between the flat upstream face of the plate and the cylindrical edge of the orifice approximately square and smooth. Microscopic examination showed in many cases that this entrance corner was by no means perfect, but with few exceptions failed to reveal differences of behavior that could be traced to these visible imperfections of finish.

The original article describes the methods of measurement and gives formulas for discharge coefficients of orifices, first for liquids and then for gases. The various factors affecting the fall of pressure are discussed, in particular the location of the pressure taps. The results are considered for throat taps, flange taps, and pipe taps, and the three sets of results are compared.

Among other things discussed are the effects of viscosity, and geometrical similarity and the influence of pipe diameter. In an appendix the theory of flow nozzles and the impact tube is presented. The authors arrive, among other things, at the following conclusions:

a The discharge coefficient of an orifice for air does not depend on or vary with the absolute static pressure.

b The hydraulic discharge coefficient based on either upstream or downstream static pressure is not a constant but varies with the ratio of the two pressures. At low static pressures and high differentials these variations may be of serious importance, and ignoring them may lead to errors of several per cent in the computed rate of flow. This difficulty may be avoided by using a discharge coefficient based on the mean of the two static pressures.

c Very slight changes in the condition of the edge of an orifice may have an appreciable effect on its discharge coefficient; and to produce duplicate orifice plates which have the same discharge coefficient within ± 0.5 per cent requires very careful mechanical work, even when the diameter of the orifice is 1 in. or more. The commercial plates loaned to the authors were quite as good in this respect as the plates made at the Bureau of Standards.

d The difficulty of duplication increases as the size of the orifice is reduced, and if a standard table of discharge coefficients is to be relied upon, and the orifices not tested individually, it is advisable to use the largest orifice practicable within the range of diameter ratios covered by the variable tables.

e Tables in the original paper represent average results obtained from well-made orifices installed in 6-in. and 8-in. pipes, with a straight run of at least 120 pipe diameters upstream and 30 downstream. Similar orifices installed in a 4-in. pipe gave higher coefficients; but the experiments were not adequate to the establishment of a general relation between discharge coefficient and pipe diameter, even for this particular mode of installation, and any such relation must be expected to vary with the nature of the installation. (H. S. Bean, E. Buckingham, Mems. A.S.M.E., and P. S. Murphy in *Bureau of Standards Journal of Research*, vol. 2, no. 3, Mar., 1929, pp. 561–658, 12 figs., *eA*)

ENGINEERING MATERIALS (See also National Defense: Manganese Deposits in South Africa)

Creep of Steam-Turbine Metals

THE main difficulty in the case of materials used in steam-turbine construction arises in connection with creep, since it has been very definitely demonstrated that an ordinary tensile test may afford a very inadequate idea of the actual strength of materials at high temperatures. Certain alloy steels, indeed, are claimed to be free from the defect, and it may be that resort must be had to these if temperatures of 900 deg. fahr., such as Mr. Guy suggested as possible, are to become common. In the meantime, however, Mr. R. W. Bailey has suggested that liability to creep may not necessarily preclude the use of material at high temperatures. Mr. Bailey holds, indeed, that creep is a normal property of ordinary steel, taking place at all temperatures, but at a rate which diminishes exponentially as the temperature falls. It is suggested, accordingly, that all that is necessary is to adopt proportions such that the total distortion by creep never becomes excessive during the working life of the plant. On this basis, Mr. Guy suggested that it will be as safe to work at 900 deg. with a pressure of 400 lb. per sq. in. as it is to work with a pressure of 800 lb. at 700 deg. fahr., and he notes that the former combination will have the higher thermal efficiency.

Mr. Bailey's proposal is as ingenious as it is bold, but for our part we are inclined to think that the weight of evidence is rather

against the hypothesis that, like the poor, creep is ever with us. Some support for Mr. Bailey's view might perhaps be derived from a paper read last May before the Institute of Physics, by Sir F. Dyson, the Astronomer Royal. From this paper it appears that the Short astronomical clock has been brought to such perfection that a steady secular lengthening of the pendulum rod has been definitely demonstrated. The losing rate of the clock is increasing each successive month by 0.011 sec. per day, which implies that the pendulum lengthens by one micron in 110 days. Apparently, however, the material used for the rod is of the invar type, and these alloys are known to be subject to secular changes even when not under stress. Different varieties show the fault in different degrees, and it is claimed that by the addition of chromium the rate of change has been reduced to one-tenth of what it was in some of the older makes, but apparently the creep has not been reduced to zero. There is, so far as we are aware, no evidence that ordinary steels at ordinary temperatures are similarly afflicted, and in fact it seems difficult to reconcile with the hypothesis of a universality of creep some of the experiments made in Lord Kelvin's laboratory many decades ago. It was then found that a steel wire which broke forthwith when loaded with a weight of 45¼ lb. could be "trained" to carry 49¼ lb. by loading it for a few days with a weight of 43 lb.; and, in fact, during further experiments the tensile strength was thus raised to 57¼ lb. It is difficult to see how this could be done if creep occurred at all temperatures. Again, the Laurentian Mountains are considered, we understand, to be something like 1000 million years old. If creep were a general phenomenon occurring at all temperatures, it would seem that they must long since have sunk into the earth.

It seems to us much more probable that at all temperatures short of fusion that there is a definite limit to creep. Discontinuous phenomena are becoming more and more widely recognized, and indeed many apparent continuities are really the statistical result of innumerable discontinuities, so that there is no a priori reason for assuming that the relation between temperature and creep can be expressed by a continuous function.

There can be no room for difference of opinion as to the need for the further investigation of the properties of materials at high temperatures. Possibly some useful information might be obtained by collating the experience of furnace builders and users, but much more definite data are required. (Editorial in *Engineering*, vol. 127, no. 3292, Feb. 15, 1929, pp. 203–204, *g*)

Tests on Aging and Recrystallization of Boiler Plates

THE investigations here described have been carried out for the Technical Commission of the Association of Plate Manufacturers and were made at the Kaiser Wilhelm Institute for Iron Research in Düsseldorf. Among other things the tendency of boiler plate to form coarse-grain recrystallization has been investigated. Previous investigations, among them those of Goerens, have shown that additions of nickel modify favorably the undesirable phenomena of aging and that nickel also tends to suppress coarse recrystallization of steel.

The tests were made on fourteen kinds of boiler plate about 0.8 in. thick, of varying chemical composition, with carbon from 0.06 to 0.29 per cent and silicon from traces to 0.19 per cent. The nickel was present only in two kinds of steel and varied from 3.18 to 4.80 per cent.

The article describes the methods of testing. Test pieces were subjected to stretching at room temperature and thereafter were left alone for periods of 3, 14, 30, 90, and 270 days, at room temperature varying from 17 to 22 deg. cent. In addition, artificial aging was resorted to on some of the samples, which after stretching were placed for two hours into an oil bath maintained at 200 deg. cent. (392 deg. fahr.) and were then tested in tension and notch shock. The notch strength was also determined in addition to room temperature at temperatures ranging at 20, 50, 100, and 200 deg. cent. (68, 122, 212, and 392 deg. fahr.) The data of these and other tests are given in the original article in the form of figures which cannot be reproduced here because of lack of space.

Among the results of tests, the following may be noted: Stretching up to 4 kg. per sq. mm. (5680 lb. per sq. in.) above the elastic limit either left the tensile strength of the test pieces unaffected or affected it only to a very small extent. With increase in the duration of aging there was as a rule an increase in tensile strength but only to a very small extent. On the whole it has been found that, in the majority of cases under investigation, letting the sample lie for a period of nine months does not increase the tensile strength to the same effect as heat treating to 200 deg. cent. (392 deg. fahr.).

Elongation and Contraction. The changes in elongation and contraction produced by stretching proved to be quite small. In the majority of cases there was an unimportant decrease. With the increase of the time of aging the elongation became as a rule smaller, while the changes in contraction with increase in time of aging were not uniform. In some samples there was a decrease, with others an increase in contraction, while all the artificially aged samples showed a decrease in elongation and an increase in contraction.

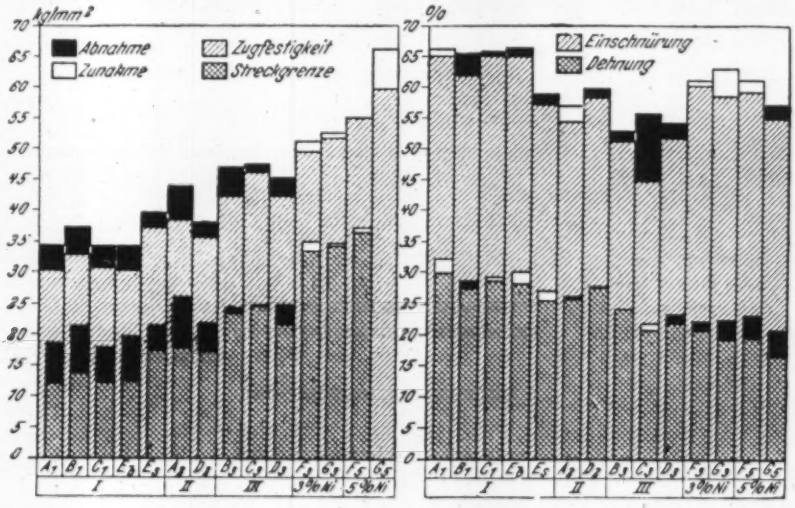
Notch Strength. By far the most profound changes due to stretching and aging were produced in notch strength. Notch strength is materially lowered in some test pieces by the action of stretching alone. For example, in the case of one sample even small stretching lowered it from 19.4 m-kg. per sq. cm. (903 ft-lb. per sq. in.) to 10.8 m-kg. per sq. cm. (503 ft-lb. per sq. in.) (in stretched condition). This decrease in strength grows with increase in the period of aging as shown by curves in the original article. The curves of notch strength and temperature as functions of the time of aging show in some cases a considerable irregularity, and, for example, in one case it was found that a lower notch strength was indicated after an aging period of 30 and 90 days than after a period of 270 days. Some samples showed a maximum strength at 14 days, with lower values for both shorter and longer periods, and, in general, it has been found that the variation of notch strength with aging is quite different with different samples.

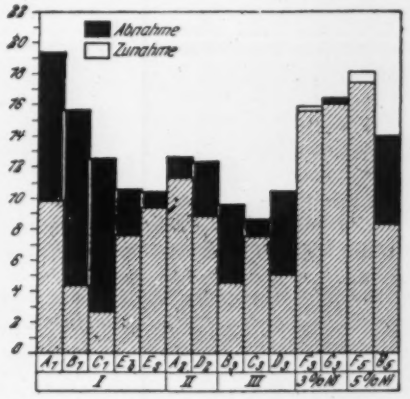
Quite interesting observations were made on the effect of temperature on notch strength in artificially aged samples, particularly very low and very high temperatures. At 0 deg. cent. (32 deg. fahr.) most of the straight-carbon-steel plates show a very low notch strength after aging, while plates containing nickel are remarkable for a very high strength. At 50 deg. cent. (122 deg. fahr.), however, the superiority of aged nickel-alloy plates as compared with straight-carbon-steel plates disappears practically completely, while at 200 deg. cent. (392 deg. fahr.) the mild steel plates appear to be superior in regard to notch strength to hard-steel or nickel-alloy plates. What is more, notched-strength values appear to be much more uniform at 100 deg. and 200 deg. cent. than they do at room temperature.

Recrystallization. Pieces intended for rupture and notch-strength tests were first stretched to an extent of 10 per cent in a 50-ton Amsler testing machine. The straight-carbon-steel test pieces were then held for one hour at 780 deg. cent. in a gas-heated muffle oven and allowed to cool slowly in the oven; the nickel-steel samples were treated in the same way but heated to a temperature of only 650 deg. cent. (1202 deg. fahr.). In both cases the heating temperature lay below the A_3 point which for 3 per cent nickel steels lies at 704 deg. cent. (1310 deg. fahr.) and for 5 per cent nickel steels at 693 deg. cent. (1274 deg. fahr.). The

results of tensile-strength and notch-shock tests of recrystallized samples are shown in Figs. 1 and 2 (the capitals with subscript numbers at the bottom of the figures refer to key numbers for the various steel samples. Groups I, II, III are straight carbon steels).

As appears from Fig. 1, the critical stretching and heating of all unalloyed boiler plates produced a lowering of the yield point and tensile strength of the samples, while in nickel-alloy plates there occurred a small increase in both yield point and tensile strength. While the changes in tensile strength of unalloyed plates appear to be independent of the chemical composition, the milder plates show a greater decrease in yield point than the harder ones. The elongation of unalloyed plates has changed but very little. In the majority of the cases there is a slight increase, and in two samples (B1 and D3) there was a slight decrease. On the other hand, all the four nickel-alloy plates show a decrease of elongation. In the matter of contraction the situation is less clear, but as regards unalloyed steels the dark fields prevail, which means that contraction decreased. In nickel-alloy plates, on the other hand, the contraction seems to have increased. Fig. 3 would indicate the changes in notched strength due to the critical stretching and heating. In all of the unalloyed samples of plate there was a clear decrease, which is particularly large in mild steel samples. Of the high-carbon plates some (E_2, A_2, C_2) show only a very small decrease, while others (B_2 and D_2) are affected a good deal more. When we come to nickel-alloy plates, one, G_5, shows a material loss in notch strength (about 6 m-kg. per sq. cm. = 280 ft-lb. per sq. in.), while the three others are only little affected, either upward or downward. An investigation of the structure of steel shows that a 10 per cent stretching and one hour of heating did not produce a very good coarsening of the grain. Apparently a stretching of 10 per cent was not critical in all cases. Further tests in this direction are under consideration. On the whole the tests on recrystallization have basically confirmed the conclusions obtained by previous investigators, namely, that the tendency toward coarse-grain formation and resultant lowering of the yield point and increase in sponginess are particularly prominent in low-carbon-steel plates, and are more or less suppressed in high-carbon steels and alloy steels. (A. Pomp in *Zeitschrift des Bayerischen Revisions Vereins*, vol. 33, nos. 1, 2, and 5, Jan. 15, 31, and Mar. 15, 1929, pp. 7–8, 26–27, and 93–96, and one large sheet of drawings, 30 figs., *eA*)





FIGS. 1, 2, AND 3 CHANGES IN PHYSICAL PROPERTIES DUE TO RECRYSTALLIZATION AS A RESULT OF STRETCHING AND HEATING (Fig. 3 shows notch-shock test values. Ordinates = kg per sq. mm.; *Abnahme*, loss; *Zunahme*, increase; *Zugfestigkeit*, tensile strength; *Streckgrenze*, elastic limit; *Einschnürung*, contraction; *Dehnung*, elongation.)

HYDRAULIC ENGINEERING

Models to Predict Performance of Hydraulic Structure

THE Alabama Power Co. has established for its engineering department a hydraulic laboratory in which models of developments are built. It is claimed that with these models future results can be predicted with high accuracy.

To reduce the model to a working scale, it is frequently necessary to use wide ratios. The model of the Mitchell Dam backwater suppressor was $^1/_{24}$ of the actual size of the structure. The model dam was faced with galvanized iron to represent the irregularities to be expected on good concrete. This factor has been proved by actual operation at Mitchell Dam, where results have been exactly as predicted by the model.

The Martin Dam development presented several interesting problems which were worked out satisfactorily with a small model before the dam was constructed. It was necessary to construct this model to a scale of $^1/_{100}$ to study the spillway conditions at the plant. In addition to the complete spillway, consisting of 20 gates, it was necessary for the laboratory to reproduce the equivalent of 1000 ft. of river bed below the dam. By the use of this model it was possible to design the spillway aprons so that the destructive action of the flood water on the river bed was reduced to a minimum.

In the spring of 1928, a flood of 60,000 cu. ft. per sec. passed over Martin Dam. The spilling basin and banked spillway were given a thorough test at this time and the structure proved a complete success, working exactly as predicted in the $^1/_{100}$-scale model.

The Tallassee Falls development presented the second backwater problem to be investigated. In this case a $^1/_{100}$-scale model was constructed representing the complete development, with sufficient river bed below the dam to determine a true backwater curve. The balance between cost of concrete penstock and tailrace excavation called for the power house to be located half-way up the rapids. The best data available as to the correct elevation of backwater at this location called for a height of concrete structure considerably greater than was anticipated. The model, however, gave the correct height at 15 ft. lower than the records, netting a saving of 15.5 ft. in the height of the power-house substructure. Many other problems have been handled on this model, such as coffer-dam heights for construction and probable flood elevation affecting adjacent structures.

Small models of this type are kept in the laboratory throughout the construction period of the project. It is gratifying to be able to reproduce a flood of any magnitude up to 200,000 cu. ft.

per sec. as desired, without waiting 25 to 50 years for nature to furnish the necessary water.

By the use of models, spillway coefficients can be obtained to a high degree of accuracy, turbine efficiency can be determined, water passages can be altered and improved, backwater curves can be established, treatment of spillway aprons for discharge can be determined, gate pressures and operations can be estimated, and numerous other associated problems can be worked out in a satisfactory manner. (*Power Plant Engineering*, vol. 33, no. 8, Apr. 15, 1929, pp. 486–487, 3 figs., *dg*)

INTERNAL-COMBUSTION ENGINEERING

The Scavenging of Two-Cycle Internal-Combustion Engines

THE fact that a residue of burned gases in the cylinder reduces the capacity of the engine has been known for a long time. Wm. B. Chapman (Mem. A.S.M.E.), of the Chapman-Stein Furnace Co., has now developed a method of scavenging which consists in causing the incoming charge to flow along the cylinder wall in a thin annular film at high velocity to the opposite end of the cylinder and then double back behind the spent charge through the entire length of the cylinder, pushing the burned gases out ahead of it. The path of flow of the incoming charge and outgoing gases is directed by the contour of the piston head.

Comparative tests were made on a two-cycle, single-cylinder $3^1/_2 \times 3^1/_2$-in. gasoline engine with crankcase compression. Before the changes on the engine were made it was found to develop 28 lb. brake mean effective pressure and the speed range was found to be limited to from 450 to 900 r.p.m. The piston was then removed and replaced by one arranged to produce a horseshoe-shaped path for the incoming charge. The engine then developed 32 lb. brake mean effective pressure and could be operated under full load or at no load at speeds varying from 200 to 1200 r.p.m. With a still different shape of piston the brake mean effective pressure was raised to 38.8 lb. and the speed could be increased to 1800 r.p.m. (*Power Plant Engineering*, vol. 33, no. 8, Apr. 15, 1929, pp. 467–469, 4 figs., *d*)

The Berna Engine as a Brake on Trucks

THE engine is so arranged that when a hand lever is turned each cylinder is converted into an air compressor, a unique feature being that while the inlet valves remain closed the exhaust valves are lifted twice every revolution of the camshaft so that the four-stroke engine is converted into a two-stroke air compressor. The air is admitted, compressed, and released at every crankshaft revolution and not merely compressed and expanded, under which condition the retarding effect would be considerably reduced. Arrangements are made also to reduce the normal compression pressure to provide easy starting. The cycles of operation are shown graphically in the original article.

It is stated that with the engine brake in operation a retarding pressure of approximately 5 atmos. per revolution is obtained on the compression stroke of each piston, which is of course transmitted through clutch, gear box, and back axle to the road wheels, It is also claimed that the retardation is equivalent to 80 per cent of the normal engine power. An important advantage, too, is that as the inlet valves remain closed they do not become choked up with carbon during the use of the engine brake, while the pumping of air has considerable cooling effect on the engine cylinders. (*Motor Transport*, vol. 48, no. 1257, Apr. 15, 1929, pp. 433–436, illustrated, *d*)

The New Axella Carburetor

IN GENERAL construction the Axella carburetor follows normal practice, its distinguishing characteristic being the U-tube and the use of the sump that forms therein. The makers of this carburetor consider (on the grounds of economy) that little can be done with the main jet in any carburetor, that the pilot jet is the bugbear, and that positive and automatic control of this element is the only way to secure economy.

In the Axella the main-jet orifice is a little below the fuel level in the float chamber. Thus the small head thereby obtained automatically causes the gasoline to discharge from the main jet into the U-tube and create a sump of free gasoline when the take-off—via the venturi—decreases with the closing of the throttle. The existence of this sump is absolutely dependent upon engine speed, and so is positively controlled. The pilot jet is fed solely from the sump. Consequently it can only obtain fuel when the sump is in being. It can now be seen that the Axella is really a two-stage carburetor in which the jets cut in and out, dovetailing their functions in such a manner that there is not the slightest "blind spot" at the point of switching over. It may be as well to state here that when the engine is running fast the main jet is called upon to supply its maximum amount of gasoline direct to the engine via the venturi or choke tube. As the pilot jet absolutely depends for its supply upon the excess of gasoline allowed by the main jet at the slower speeds, it is evident that when the main jet is worked to full capacity no fuel is available for the supply of the pilot jet at these higher speeds. As the makers believe that fuel wastage only occurs as the result of pilot jets continuing to supply the engine when pilot-jet action is no longer required, they may be said in this case to have eliminated this cause of uneconomical running.

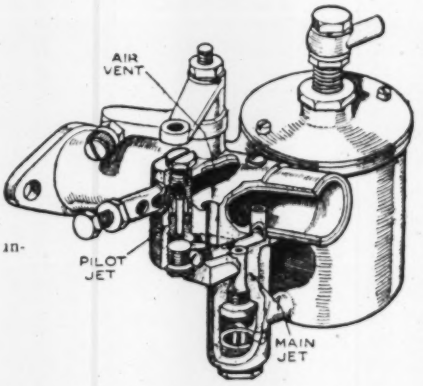


FIG. 4 THE AXELLA CARBURETOR

The author of the article states that he recently witnessed a bench demonstration of the carburetor fitted to a 10-hp. Dorman engine. An interesting feature of the trial was the testing of the mixture strength by means of an extra air valve placed between the carburetor and the cylinder block. An immediate falling off of power coincided with the slightest opening of this valve at any throttle position, thus clearly indicating that the quality of the mixture was such that it could not stand the slightest weakening.

There was no hint of a "flat spot" anywhere in the range, the engine pulling on full throttle to the last revolution. From the slow-running position under heavy load the engine responded without laboring to the sudden full opening of the throttle. Starting up from cold was practically instantaneous—there being no occasion to muffle the air intake. No provision for flooding is made, which, in the circumstances, seems to be quite unnecessary. (*Motor Transport*, vol. 48, no. 1257, Apr. 15, 1929, p. 437, illus., *d*)

MARINE ENGINEERING

Pulverized Fuel for Marine Boilers—The Brand System

THE paper covers two subjects, one being the general method of handling pulverized fuel for marine boilers, and the other the Brand system of burning pulverized fuel. There are several

schemes for handling the fuel in marine installations. Scheme A consists in loading the fuel from the shore or floating stations into the tank bunkers of a vessel and thence removing it pneumatically or mechanically to the burners. This scheme offers the advantage of dustless coaling through pipes at a high rate of intake. The cost in London for bunkering ordinary coal from lighter to steamer and trimming is 3s. 3d. per ton and the cost of trimming on board ship from bunkers to stokehold plates from 6d. to 9d., a total of, say, 3s. 9d. per ton. The cost of pulverizing coal in quantities is about 2s. 3d. per ton, and the cost of injecting it on board from 3d. to 4d. per ton, a total of 2s. 7d. per ton. These figures include interest, repairs, and depreciation on the plant, but not the cost of maintaining the lighter, which would bring the overall cost to about 4s. per ton.

Slack of good quality may be purchased at 3s. per ton less than the coal from which it is derived, which would give an additional economy.

In scheme B-1, coal in slack or run-of-mine form is loaded into the vessel's bunkers. It is then pulverized on board ship and directly delivered to the furnaces.

Scheme B-2 is similar to B-1 as far as the pulverizer. From the pulverizer, however, the coal is delivered to a storage bin wherein the coal dust is precipitated and the conveying air returned to the suction side of the pulverizer. The bin holds enough fuel for over 4 hours' steaming, which permits the pulverizer to be stopped while the fireman's attention is required to look after the boiler water and steam on entering or leaving harbor. It also permits the pulverizer to be stopped while ashes are being withdrawn, coal rimmed, or grinding elements of the pulverizer replaced.

It would appear that scheme A offers the greatest economy to the ship owner, while schemes B-1 and B-2 offer the same boiler efficiency. Scheme B-1 gives a varying boiler efficiency and very little reduced power for pulverization and burning, and on these grounds there would appear to be little to recommend B-1 as compared with the other two schemes, in fact.

Schemes A and B-1 are identical from the burner onward. The length of path necessary to burn a particle of coal varies from 30 ft. for a coal of high volatile content to 45 ft. for anthracite, and in the old long-flame system of combustion this meant that the boiler settings had to be very high to secure this length of path for the particle. To secure rapid consumption of an incandescent particle it is necessary (*a*) that the surface of the particle exposed to oxidization be as large as possible, (*b*) that the temperature at which the burning takes place be as high as possible, and that the gases emitted by and enveloping the particle, of which the conductivity is low, be removed as rapidly and as often as possible.

Two types of prefurnace are in use, and each type consists of a casting projecting a short distance into the stokehold having a slag pit and ash door in the lower portion, and around the perimeter, ribs directing the air toward the secondary air valve. This portion of the prefurnace is connected to the preheated-air ducts. The prefurnace is secured by clips to the furnace, and the other end is closed with a hinged door. To the latter is secured a sleeve in which a number of ports are cut. Surrounding this sleeve is a loose one having slots and directing vanes on it. The loose sleeve is worked from the outside by means of a rack and pinion. The burner pipe passes through the center of the door, and to its exterior end a flexible pipe leading from the pulverized-fuel feeder is attacked. On the outside of the burner slides the slip pipe.

In the mouth of the latter is set the burner tip, the position of which in relation to the air inlet can be varied at will, so that when lighting up, the burner tip is placed in an extended position, and after the refractory material surrounding it has become incandescent, it is withdrawn to a position where it is guarded from excess of temperature by the incoming secondary air. The amount of secondary air can be varied in exact proportion to the amount of coal burnt, by rotating the moving sleeve over the closed one. The incoming stream of secondary air is rotated in the opposite direction to that of the primary air, the result being a vortex producing a very high degree of turbulence.

From the point of vortex motion the greater mass of secondary air assumes mastery over the primary air, and both rotate in the same direction, following the helical path previously referred to. If the flame be watched through the back of the combustion chamber, this turbulent and subsequent rotary motion can be clearly observed. After disconnecting the pipe leading from the ready-use bin to the burner pipe, the door may be swung open and ingress to the furnace be obtained. A ring of brickwork 18 in. long is fitted within the furnace, and the bottom of the furnace is protected by a ring of brickwork in the lower third of its circumference for 3 ft. from the front; the latter terminates in a bridge 9 in. high. This forms a bath in which the slag can deposit, and in which it is maintained in the molten state. So far, in boilers of either the marine or Lancashire type, no slag particles have been observed beyond the bridge even after days of continuous steaming. No difficulty is experienced in obtaining a heat release of 75,000 B.t.u. per cu. ft. of combined space of furnace and prefurnaces.

Tests of the Brand system on a Scotch marine boiler and on a Lancashire boiler are reported in the original article. (Paper by Engr. Capt. J. C. Brand R. A. N. (ret.) before the Institution of Engineers and Shipbuilders in Scotland, Mar. 12, 1929; abstracted through *Iron and Coal Trades Review*, vol. 118, no. 3186, Mar. 22, 1929, pp. 433–434, 2 figs., *de*)

MECHANICS

The Shearing Strength of Bolted and Riveted Joints

ACCORDING to the theory of elasticity, when the value of m lies between 3 and 4, the ratio τ/σ ranges from 0.70 to 0.80. Results of tests made by various investigators are in good agreement with each other and with the above figures, and, for example, tests carried out quite recently by the author of the present paper give values of 0.74 for carbon steel and 0.78 for silicon steel. The shearing strength in riveted joints is considerably in excess of that of the rivet material, not only because of the presence of friction but also because of the increase of strength imparted to the rivet in pressing the set head, as well as because of the upsetting in hammering the head on. Numerous tensile tests on double-riveted butt joints have given determinations of the actual shearing strength of such joints. In 1927 and 1928 new tests were carried out at Diósgör on behalf of the Hungarian Steel Board. In these tests rivets and riveted joints made of mild steel, carbon manganese steel, and silicon steel were investigated. While the values found for pure shearing strength in the rivet material in these recent tests were in good agreement with those found previously, the values of shearing strength for the joints were somewhat lower. Furthermore, in the Diósgör tests various joints, both hand-made and made by pneumatic hammers and riveting machines with 5 and 10 sec. pressure, were investigated, and it appears that the manner of riveting has no influence on the strength of the joint and at the beginning of slipping there is no notable difference between hand and machine riveting. It was found, however, that machine riveting, when a longer period of pressure is employed, causes a material increase in the yield point. It was also found that the ratio of the shearing strength τ_v of the riveted joint to the tensile strength σ_n of the rivet material is noticeably greater in the case of silicon steel than with carbon steel. Nevertheless it would not be advisable to increase corre-

spondingly the shearing stress in silicon steel because slipping with silicon steel not only does not begin later but actually begins a little earlier. Tests with lap joints indicate a somewhat though not very much lower shearing strength, probably because the stress is applied in a less favorable manner. According to these tests and data from previous work the following values of τ_s/σ_n may be applied: Mild steel 0.80; carbon steel, 0.84; silicon and nickel steels, 0.88. These values represent the shearing strength at the rivet-hole diameter and not at the rivet-shank diameter (as is usually taken, for example, in Hungary). If the latter is used an increase of safety from 8 to 10 per cent results.

According to tests made by Engesser and Considère the frictional resistance referred to the shearing surface of the rivet amounts to from 800 to 1000 kg. per sq. cm. (11,400 to 14,200 lb. per sq. in.). The German Railway Association has obtained on the basis of its own tests values of 600 to 700 kg. per sq. cm. (8500 to 10,000 lb. per sq. in.) in hand-driven and compressed-air driven rivets, and 900 to 1000 kg. per sq. cm. (12,800 to 14,200 lb. per sq. in.) in machine riveting. The comparative factors for friction in hand, compressed-air, and machine riveting are according to German tests 100 : 105 : 145; according to Austrian tests they are 100 : 105 : 114; and according to Diósgör, 88 : 91 : 100. Considère has also found that the maximum frictional resistance is reached at a temperature of 600 to 700 deg. cent. (1112–1292 deg. fahr.) and the maximum shearing strength at 550 to 600 deg. cent. (1022–1112 deg. fahr.). This confirms the old practical rule to the effect that in good riveting the rivet head at the end of the riveting must still show a red glow. These tests apply, however, only to wrought-iron rivets and do not hold good for steel rivets. The pressure required for upsetting the rivet shank is for wrought-iron rivets from 9 to 10 tons per sq. cm. (128,000 to 142,000 lb. per sq. in.); for steel rivets having a tensile strength of 4500 to 5000 kg. per sq. cm. (64,000 to 71,000 lb. per sq. in.) the pressure should be from 11 to 12 tons per sq. cm. (156,000 to 170,000 lb. per sq. in.), and for rivets having a tensile strength of 5000 to 5500 kg. per sq. cm. (71,000 to 78,000 lb. per sq. in.) from 12 to 14 tons per sq. cm. (170,000 to 200,000 lb. per sq. in.). Bach and Baumann recommend a final pressure for wrought iron of from 7 to 8 tons per sq. cm. (10,000 to 11,400 lb. per sq. in.), and warn that damage may occur to the edges of the hole if the final pressure is made greater than that. Good riveting depends not only on applying a proper period of pressure but on using increased pressure with increase of diameter of the rivet shank. Modern automatic riveting machines can satisfy these requirements. (Dr. of Engrg. e.h. Stefan Gállik in a paper before the Second International Convention for Bridge and Highway Construction, Vienna, Sept. 24–27, 1928; abstracted through an article by von Findeisen in *Der Bauingenieur*, vol. 10, no. 12, Mar. 22, 1929, pp. 213–124, *g*)

NATIONAL DEFENSE

Progress in Army Ordnance

THE following is a composite abstract from several articles in the January–February, 1929, issue of *Army Ordnance*.

One of the most important things that happened as a result of the World War is the recognition of the importance of proper development of ammunition, while previous to the war the main work was directed toward the gun. In the development of ammunition one of the very important problems and probably one of the most difficult was the obtaining of satisfactory fuses. The so-called Westervelt or Caliber Board appointed immediately after the war recommended that a mechanical fuse should be developed and stated that it is especially desirable to reduce the type of fuses issued to any single organization. Such a mechanical fuse has been developed and small production is now being obtained at one of the arsenals. It is further expected that one type only of the new fuse will be necessary for a single organization.

The research and development work of the Ordnance Department in the field of ammunition is carried on chiefly at the Picatinny Arsenal, Dover, N. J.

Every research problem which has been undertaken at the arsenal has resulted from a recognition of the fact that at least one of the four factors involved has not thus far been provided for, in an ideal manner, in the existing types of ammunition. Thus under the factor of utility may be grouped problems which deal largely with improvement in design. Attempts to develop a detonating compound which will be free from the known faults of mercury fulminate, fuse powders which will not have the numerous deficiencies of black powder, colloiding agents for nitrocellulose which will not have the volatility and hydroscopicity of the common ether-alcohol solvent and yet give a power that will function satisfactorily in the gun—these are all efforts to increase the utility of certain components of a round of ammunition so that the round as a whole will function more ideally. Other problems of this general nature which have received attention have connection with the development of more efficient boosters for artillery shell, a decidedly weak point in much of the ammunition used during the past war, and with pyrotechnic signals which will give more intense color and greater candlepower than former types to make them adaptable for use at greater range.

Under the second point, availability, are grouped all problems which have arisen from the knowledge that certain raw materials necessary for the production of ammunition in accordance with existing specifications could not be obtained in this country in sufficient amount to meet the demands of a major emergency. The lacquer formerly used as an interior coating for shell required shellac as an ingredient. Since this material is not produced in this country, it was obviously desirable that a composition be established which would readily be available and capable of serving its purpose at least as well as the lacquer formerly used. The silk yarns which have been specified in the past for the weaving of cartridge-bag cloth are obtainable only from the Orient, and this lack of availability of silk has made necessary considerable experimentation with cloths prepared from other yarns which can be produced in the United States. The extent to which the particular coal-tar products, used as starting materials in the preparation of the standard high explosives, could likely be produced in time of any emergency has been carefully considered, and if deficiencies appeared probable, research programs were outlined for a study of new compounds which might be used to supplement those formerly established as standard. Here again the necessity for the research was not a matter of lack of utility of the standard material, but rather the lack of availability.

The arsenal investigates also questions dealing with production as well as such problems as stability of explosives, influence of impurities in certain explosives, etc. In the field of projectile design one of the developments of interest to mechanical engineers is the substitution of seamless drawn tubes for hydraulically pierced shapes in the manufacture of artillery shells. This process is completely described in an article by G. P. McNiff. The main advantage of this process of manufacture is the saving in machining and the fact that all the machine work can be done on the usual light machine-shop equipment instead of requiring special-duty single-purpose machines.

On an experimental order some idea of the difference in cuts required can be gleaned from the fact that the 75-mm. hydraulically pierced forging weighed 24 lb. as against 17.25 lb. for the piece from the seamless-tube method, or an increase in weight of 38 per cent over the lighter forging. Naturally such a difference

in the amount of metal to be removed creates a saving in time as well as in any transportation costs that might be incurred. This saving in weight is also in evidence on the 155-mm. shell, a small quantity of which were made at about the same time as the 75's, the weight of the tubing blank being only 127.8 lb. as against 151 lb. for the old-style forging. The operations performed on the 155's were exactly the same as for the 75's, and with two exceptions were the boring of the inside diameter, which was done on a horizontal boring mill, and the closing of the base, which was accomplished on a somewhat larger but exactly similar forging machine. (*Army Ordnance*, vol. 9, no. 52, Jan.–Feb., 1929, *g*)

Manganese Deposits in South Africa

THIS matter is of interest to the United States from two points of view. In the first place it gives a new source of a material which has to be imported by this country in considerable quantities. In the next place it opens up the possibility of obtaining unlimited supplies of manganese from a source other than Russia, and in this respect it is of importance from the point of view of national defense as indicated by the experience of the World War. The United States Department of Commerce has recently issued a general survey of the situation with regard to the world trade in manganese. It is claimed that this report does not do justice to the South African deposits. It is stated that the Postmasburg manganese deposits have been proved over a length of 40 miles from south to north, and that government geologists have estimated 75,000,000 tons of high-grade ore available for mining. Approximately 60 per cent of the ore on the southern farms shows on analysis between 50 and 59 per cent of manganese content. A railway to carry the manganese is being constructed by the South African Government.

For some time past it has been reported that the supply of Russian ore throughout the world has been drawn from stocks which were accumulated partly by the Harriman interests, and that when these stocks were exhausted the supply of Russian ore for the world's market would be very uncertain. It is furthermore felt that the cut in price recently carried out by Russia cannot be long maintained, and that the price is bound to rise. On the question of price, the South African deposits are in a favorable position, as the South African Government have interested themselves in the deposits and have quoted a freight rate for conveyance of the ore to port so low that South African manganese ore will be able to compete with and even undersell any other ore at present on the market if this is considered a desirable thing to do.

At the present moment a British organization has obtained control of the South African manganese deposits, but it is by no means certain that they intend to retain this control. The company, the British Swiss International Corporation, Ltd., is a purely financial house and is not interested in steel production or the supply of ore, and it would appear that the race for control of South African manganese has merely been shifted from South Africa to Britain, and whichever country obtains control of these deposits will be in a very favorable position in so far as their manganese supplies are concerned. (H. M. Pezzani, statistician to F. N. Pickett & Son, Paris, in *The Iron and Coal Trades Review*, vol. 118, no. 3189, Apr. 12, 1929, p. 540, *g*)

OIL ENGINEERING

Trinidad Method of Handling High Pressures

THE geologic formations in the Trinidad oil fields are such as to require rotary methods of drilling. Recently deep drilling has been found necessary and high pressures have been encountered. At such gas pressures it is customary to drill in with screen or perforated pipe and fishtail bit, etc., assembled on the bottom of an oil string or liner, for which flush-joint pipe is sometimes used. This assembly (oil string, screen, and bit) is left in the hole with completion. Blowout preventers are almost always used.

Trinidad operators have developed a very successful and effective method for drilling under pressure and controlling wells at the crucial period which follows the penetration of high-pressure sands. The use of a 40-ft. "grief joint" constitutes its basic idea. A special joint of 6-in., 23 1/4-lb., 40-ft. seamless drill pipe is substituted for the usual square or fluted kelly joint. The drill pipe is rotated by means of a clamp with protruding arms affixed to the grief joint at a convenient height (about 5 ft.) above the rotary table. These arms are engaged and rotated by special posts extending upward from time to time, as drilling progresses. The pressure is controlled inside the drill pipe by the use of a series of back-pressure valves supported by pump pressure and reinforced by a master gate placed between the swivel and the grief point. The flow outside the drill pipe is controlled by the blowout preventer and a lead-seal stuffing box installed in the support above it. Single joints of drill pipe are added as each 20 ft. of hole is cut, which always leaves 20 ft. of the grief joint protruding. Thus the driller is at all times assured of the opportunity to make 20 ft. or more into the productive sand after penetrating a zone of high pressure and before having to stop to make a connection.

The following remark may be of interest as dealing with living conditions. The ready availability of good Dutch beer and other alcoholic liquors compensates many Americans for other things which they must do without. However, heavy drinkers do not long survive the hardships of tropical employment. Perhaps for this reason moderate or light drinking is the rule among sojourning Americans. One even finds a number of total abstainers in the oil fields.

Except for malaria, which is not nearly so prevalent as in other tropical countries, Trinidad is a healthy colony. The death rate in 1927 was reported as only 18.71 per 1000, the lowest figure on record. (R. E. Leigh in *The Oil Weekly*, vol. 52, no. 13, Mar. 15, 1929, pp. 23–26, illustrated, *d*)

An Instrument to Show Crooked Holes

UP TO RECENTLY crookedness of the hole in boring for oil was taken more or less as a matter that could not be avoided. Of late, however, the attitude has begun to change and there is a tendency to ask guarantees that the hole will not exceed a certain amount of deviation from the vertical. From this point of view an instrument known as the "Inclinometer" may be of interest. It was developed by Myron M. Kinley, of Tulsa, Okla.

The inclinometer is placed in the drill pipe immediately above the bit, where it records the inclination of the well hole during the drilling operation. With each withdrawal of the bit from the hole the conditions existing at the point of drilling may be noted. If it is seen that the hole is deviating from vertical, the drilling tools may be adjusted to meet the character of the formation and thus avoid excessive inclination.

The invention, according to Mr. Kinley, makes it possible also to record deviations from vertical in a drilled well at various levels. This can be done, the inventor says, by simply attaching the inclinometer to a cable and lowering it into the well tubing.

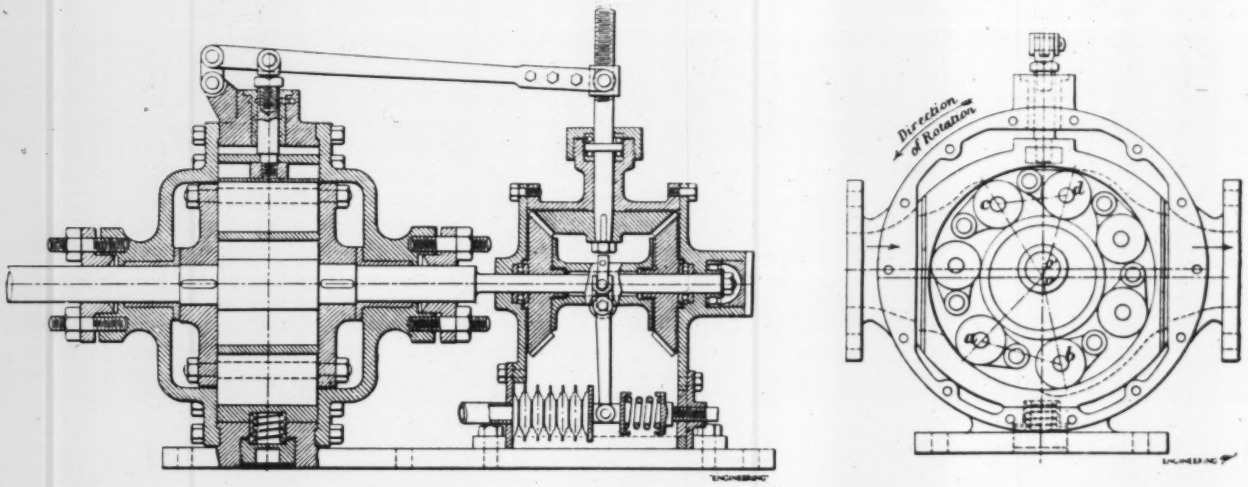
This new charting device is contained in a cylindrical watertight housing. The top is provided with a bail to which a cable may be attached when the device is used in a completed well. The lower end of the housing is externally threaded. (Thos. F. Smiley in *The Oil and Gas Journal*, vol. 27, no. 49, Apr. 25, 1929, pp. 44–50 and 151, 2 figs., *d*)

PUMPS

The Malcolm-Feuerheerd Pump

DESCRIPTION of a new type, different from the Feuerheerd pump which has been on the market for several years.

The essential features of the pump will be followed most readily from Figs. 5 and 6, the automatic-control gear, shown on the right in Fig. 5, being for the moment disregarded. The two disks or end plates, shown in section in Fig. 5, are keyed to the main shaft, and between them there is a sliding block which is shown in end elevation in Fig. 6. This block is mounted in side guides, and is roughly circular in form, a large hole being bored through the center to form a track for a number of rollers. These rollers are mounted on swinging brackets, the latter being pivoted on bolts passing through the two disks. The assembly is completed by an internal floating ring, which is located concentrically with regard to the roller track by the rollers themselves. This ring, shown in section in Fig. 5, and in end elevation in Fig. 6, is entirely free from the center shaft, there being an open space between the two. The suction and delivery ports are cut in the sliding block, and are continued through the side guides into the pump casing proper, terminating in the usual flanged openings.



FIGS. 5 AND 6 THE MALCOLM-FEUERHEERD ROTARY PUMP

In order to follow the action of the pump, it must be remembered that the ring of fulcrum bolts rotates eccentrically with respect to the roller path, the degree of eccentricity being regulated by raising or lowering the sliding block. It can be seen from Fig. 6 that the rollers approach each other as they travel toward the top of their path, and recede toward the bottom, although the reason for this is at first sight by no means obvious. If, however, it be realized that the pivot points, which are all equivalent, revolve round the point o^1 whereas the rollers revolve round the point o, in another circle, eccentric with the former, it will be clear that the roller brackets must make varying angles with the lines joining the pivot centers. Actually, the angles become smaller toward the top of the roller path, with the result that the rollers are closer together in this position, and farther apart at the bottom of the path. This can be checked by measuring the actual length of the lines *ab* and *cd*. The action of the pump is thus equivalent to one of the sliding-vane type, the pumping effect depending on the fluid entering the space between the vanes—in this case, the rollers—when this space is a maximum, and being delivered as the space becomes reduced. It has the advantage over the vane type of pump, however, that the motion is a rolling instead of a sliding one. In addition to this important advantage, it will be noticed that the pressure on the delivery side of the pump tends to press the floating ring on to the rollers on the section side, thus insuring an effective seal between the two sides; the rollers of course being held firmly on their track by centrifugal force. *Inter alia*, it may be pointed out that the pump lends itself to economical manufacture, as the majority of the parts can be machined on the lathe and grinder.

The automatic control mechanism shown in Figs. 5 and 6, may now be considered. The illustrations are of a pump manufactured for supplying the fuel to a marine oil-burning installation, and it will be noted that it has seven rollers, this large number being necessary to insure that the oil is delivered without any perceptible pulsations. We have had an opportunity to examine a diagram taken by connecting a pencil indicator to the delivery side of one of these pumps, and the variations in pressure, as traced by the pencil, are quite imperceptible. From the description of the pump, it will be clear that its capacity will vary as the sliding block is raised or lowered, and to effect this variation in accordance with the number of burners in use, the block is supported on a spring at the bottom, and is connected at the top to the lever shown in Fig. 5. The outer end of this lever is pivoted on a nut engaging with a screwed spindle, the latter terminating in a bevel wheel at the bottom. Two other bevel wheels, running freely on the main pump shaft, are in permanent engagement with this wheel, as shown, and a central sliding clutch is provided by means of which one or the other wheel may be driven from the shaft. It is evident that if one end of the clutch is engaged, the roller track in the pump will be raised, while if the other is engaged it will be lowered. The clutch-operating lever is connected at the bottom with a block, poised between a compression spring and a diaphragm box, the interior of the latter being in communication with the delivery side of the pump.

To illustrate the operation of the mechanism, it may be assumed that, at a given instant, the delivery or working pressure is 50 lb. per sq. in., the spring being adjusted so that, at this pressure, the clutch is floating. If further burners are brought into operation, the pressure in the diaphragm box will fall, when the spring will engage the clutch, and the eccentricity of the pump will be increased until the pressure again rises to 50 lb. per sq. in. Presuming that all burners are now in operation, and the order is received to increase speed, and therefore to increase the pressure on the delivery side to, say, 100 lb. per sq. in., the engine-room operator will alter the spring adjustment until the required gage pressure is attained. The clutch will then automatically be re-

leased, and the pump eccentricity will remain constant in a position corresponding to this pressure. If, on the other hand, the order to reduce steam is received, the spring is adjusted in the other direction until the capacity of the pump is equivalent to the lowest pressure required. If, in these circumstances, any of the burners are cut out, the pressure will again rise in the diaphragm box, when the gear will come into operation automatically to restore the predetermined pressure on the remaining burners. If all the burners are extinguished, the pressure in the diaphragm box will reduce the capacity of the pump to zero, and the clutch will then float. In the conditions then ruling, the roller path in the pump will be concentric with the driving shaft.

The original article describes also a small pump built for high-speed work and of somewhat different construction. A reference is made to tests of this pump carried out at the National Physical Laboratory. (*Engineering*, vol. 127, no. 3296, Mar. 15, 1929, pp. 345-346, 6 figs., *d*)

RAILROAD ENGINEERING

The Loeffler High-Pressure Locomotive

THE Loeffler system has been previously referred to in MECHANICAL ENGINEERING, vol. 48, no. 5, May, 1926, p. 512; vol. 50, no. 12, December, 1928, p. 952; and vol. 51, no. 4, April, 1929, p. 267. The locomotive here described was built by the Berlin Machine Construction Co. and will be probably placed in service this summer. It is a 2500-hp. express locomotive developing a steam pressure of 1760 lb. at a temperature of 950 deg. fahr., and is expected to effect a saving of about 50 per cent in coal and water. The furnace gases circulate through the firebox which is formed of superheater tubes, thence through the high-pressure resuperheater, intermediate-pressure superheater for low-pressure steam, high-pressure feedwater heater, and air preheater. The steam which is decompressed in two lateral high-pressure cylinders is condensed in a surface heat exchanger and generates low-pressure steam from the feedwater at about 200 lb. This steam after expanding in the middle low-pressure cylinder escapes to the stack through the exhaust pipe, which produces the draft for the furnace gases. The condensed steam on the high-pressure side of the heat exchanger is forced into the preheater by the feed pump of the high-pressure boiler and finally into the evaporator. The heat exchanger provides double storage of heat in water containers which are located on both sides of the heat-exchanger walls. (Dr. Hans Loeffler in *Railway Age*, vol. 86, no. 12, Mar. 23, 1929, p. 672, 1 fig., *d*)

SPECIAL MACHINERY

A Combination Toggle and Hydraulic Press

DESCRIPTION of a press patented by Ralph L. Seabury, of Toledo, Ohio (U. S. Patent No. 1,687,995, Oct. 16, 1928). The basic idea of the invention is the employment of a small liquid-filled cylinder or cylinders intended to prevent damage to the toggle by overload and to insure uniform pressure. A yieldable connection is provided between the crankpin and plunger or pressure member, and when the force exerted by the crankpin exceeds a predetermined maximum, the pressure exerted by a piston in a cylinder forces the plunger outward. In this manner a definite pressure is said to be obtained at each stroke of the plunger regardless of the amount of material in the mold. (*Plastics*, vol. 5, no. 4, Apr., 1929, pp. 192-193, 2 figs., *d*)

Hydraulic Press for Making Safety Glass

THIS apparatus is of the four-column type, with a rising table, the bottom platen being mounted on rollers, and arranged to run in and out of the press on rails, thus providing for the convenient handling of the sheets of glass. The top platen is steam heated, the ports being arranged in such a way as to insure the continuous circulation of the steam. The correct pressure which the press should be capable of exerting, and the most suitable working temperature, have been ascertained by careful experiment. Single presses are generally most conveniently operated by a separate hand pump, which forms a self-contained unit mounted on the base of the press, as shown in an illustration in the original article; but, in the case of a battery of presses, it may be found more convenient to utilize a low-pressure supply for raising the ram, the final high pressure necessary for completing the work being applied by the hand pump. A large number of these presses have been put into use with very satisfactory results, the demand for safety glass having grown very rapidly in the last year or two. (*Engineering*, vol. 127, no. 3292, Feb. 15, 1929, pp. 195-196, *d*)

Electrically Driven Woodworking Machinery

THE present article is largely based on British practice. The developments are substantially along two lines—the employment of the built-in-motor principle, and specially designed motors. Wadkin & Co. build woodworking machinery employing specially designed stators and rotors. The rotor can be built

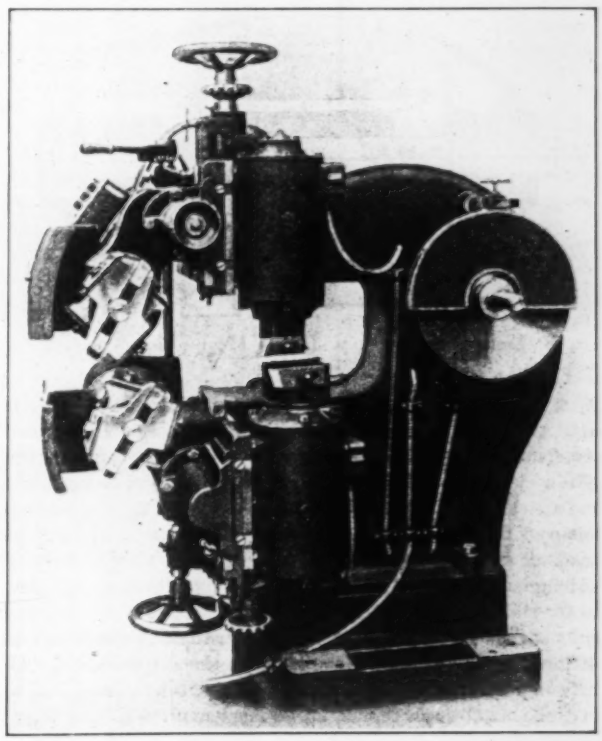


FIG. 7 TENONING MACHINE WITH TABLE REMOVED

directly on to the cutter spindle and the stator into the frame of the machine tool. The stator laminations are built up into a pressed-steel cylinder between two clamp plates, the steel cylinder then being spun over while the laminations are under pressure. The stator windings consist of former-wound coils securely held in semi-enclosed slots by wedges, and are suitably impregnated with moisture-resisting compound. The compound unites the end turns into one solid mass, so preventing the movement of individual turns and readily radiating any heat which may be generated in the windings. The stator leads are usually left two or three feet in length, so that if necessary they can be taken

direct to the starter without splicing. The leads make half a turn around the stator end windings, the soldered connections being left under the compounding, thus relieving the connections of any strain. The outside of the stator is accurately machined and ground to fit into its housing.

The squirrel-cage rotor consists of built-up laminations with centrifugally cast aluminum-alloy bars and end rings. With this form of construction, which is carried out by a patented process, there are no joints to give way, and the rotor is practically indestructible under service conditions. The end rings have fan fins cast on for assisting ventilation. The rotor bore and keyway are broached, and the rotors are statically and dynamically balanced.

The original article shows a modern motor-driven tenoning machine, clearly depicting the advantages of built-in-motor driving. On this machine are five individual motors with cutter blocks mounted directly on the spindles. Fig. 7 shows this machine with the table removed. On the left are the top and bottom heads mounted on the shaft ends of their respective motors, which can be vertically adjusted independently of each other. The top motor is also adjustable horizontally for cutting tenons having unequal shoulders; the motors can be locked in position when finally adjusted. There are two cutter

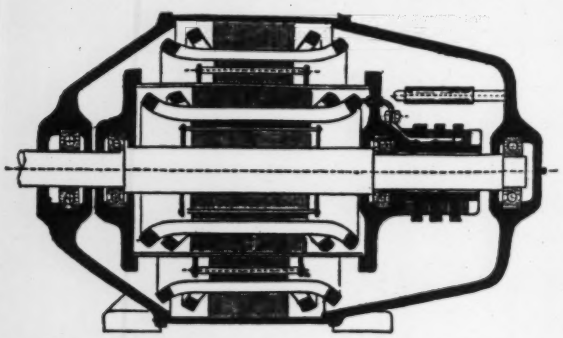


FIG. 8 DOUBLE-STATOR AND -ROTOR MOTOR FOR WOODWORKING MACHINES

blocks mounted on each shaft end, each making a shear cut 3 in. wide, thus giving a maximum width of tenon of 6 in. The spur cutters, which are set slightly in advance of the tenoning cutters, give a clean and accurate finish to the shoulders of the tenon, and are clearly seen in the illustration. The cutter blocks can be removed from the motor-shaft ends and replaced by grooving heads or saws for special work. The vertical motors carry the scribing cutter blocks, and being attached to the main tenoning-motor slides are adjustable with them. In addition, they have independent vertical and horizontal adjustment. These scribing cutters cut the shoulder of the tenon to the shape desired. The bottom motor can be fitted with a wobbling saw in order that the machine may be used for cutting double tenons.

One of the features of this machine is that each motor can be started independently from the push-button station.

Remotely controlled contactor starting is an ideal form of control for machine tools, because nothing is left to the operator, who, owing to the simplicity of control, can give his undivided attention to the work and, in cases of emergency, can disconnect his machine from the lines almost instantaneously. Should the supply fail, his contactors fall out, and as he is not called on to open a switch, which duty may be ordinarily overlooked, all danger of his machine starting when the supply is resumed is eliminated.

Planing and spindle molding machines present a rather more difficult problem to direct driving, as these machines require to run at 4000 r.p.m. and over. It is of course possible to install frequency-changing apparatus, but this is an expensive proposition, particularly if only one or two machines are required. The position is further complicated by the fact that spindle molders frequently require to run at higher speeds than, say, planing machines, which would necessitate two sets of frequency-changing apparatus. In addition, a spindle molder is required to run at different speeds for various classes of work, which demands motors of the change-speed type. Various forms of high-speed gearing were tried in the research department in the Leicester works of Messrs. Wadkin & Co., but they met with very little success.

The difficulty of a direct high-speed motor drive without frequency-changing apparatus was eventually overcome by a specially designed motor which has all the characteristics of a squirrel-cage induction motor. A sectional arrangement of this motor is shown in Fig. 8. The machine consists of two stators and two rotors, the inner stator being wound on the inner periphery of the outer rotor, which is free to rotate independently of the shaft, and is fed through slip rings from the line. The inner rotor is mounted directly on the shaft. The outer stator is wound with four poles and the inner stator with two poles. When the inner stator is connected to a 5-cycle supply through its slip rings, the inner rotor will rotate at 3000 r.p.m. If the outer stator is now connected to the 5-cycle supply the outer rotor will rotate at 1500 r.p.m., and with it the inner stator. If this is revolving in the same direction as the inner rotor the speed of the inner rotor will be 4500 r.p.m., because it is running at 3000 r.p.m. with respect to its stator, which is itself running at 1500 r.p.m. Therefore, in effect the motor consists of two squirrel-cage motors working in parallel. (*The Electrical Review*, London, vol. 104 no. 2680, Apr. 5, 1929, pp. 597–600, 11 figs., *d*)

SPECIAL PROCESSES

Cleaning Castings With a Stream of Sand and Water

THIS method is said to have been originated at the plant of the Whiting Corporation at Harvey, Ill., and combines the action of a powerful stream of water with the abrasive action of sand. The device resembles the ordinary pressure washer with the same steel room and the usual turntable in the center. The castings are placed on a revolving table in the center of the room, and the movement of the table may be properly controlled from outside. A motor-driven centrifugal pump located in a separate housing back of the washing room delivers the required amount of water under proper pressure. When the sand abrasive action is desired the water is passed through semi-eductors in the base of one of the two tanks. Here the water under 500 lb. pressure picks up the sand, which is under the same pressure, and carries it to the nozzle, the sand being centered in the stream like the lead in a pencil.

Water, sand, gaggers, everything loose, is washed across the sloping floor of the room to the first of a series of tanks in the floor. A vibrating screen over the tank catches gaggers, rods, nails, etc., while the sand and water drop through into the tank. From here the sand is picked up by low-pressure eductors and delivered either to the two tanks for reuse as abrasive or to drainage and sand driers for reconditioning for the foundry. The water passes from tank to tank over a series of weirs until it is clear for reuse. In the second last tank fine coke acts as a filter for any fine silt that may have passed over. The pump draws from the last tank in this self-supporting unit needing neither new sand additions nor additional water.

The hydraulic abrasive water will cut through burned sand on a steel casting; remove scale and rust, paint, or the metal itself if the application is maintained at one point. The water seems not only to carry the sand to the casting but to literally hold it there and rub it across the surface. The cutting power is that of

sand traveling with all the velocity of 500 lb. pressure. It will do just as effective work 6 ft. or more from the nozzle as at 1 ft. This is demonstrated daily, and the necessity no longer exists of keeping the nozzle close to the work. A steel plate 1/2 in. thick was placed 6 ft. from the nozzle and drilled entirely through in 6 min.

If rusting is objectionable it is easily prevented by the addition to the water supply of about two buckets of an anti-rust solution each day. Castings cleaned when this solution was used have failed to rust although exposed to the weather for weeks.

The violent scrubbing action of the sand not only cleans the castings but also cleans the sand itself. As it comes from the washer it is free from bond or carbon, and when freed from excess water is ready for reconditioning. (E. A. Custer, Jr., in *Iron Trade Review*, vol. 84, no. 17, Apr. 25, 1929, pp. 1118–1120, 6 figs., *d*)

Plating Steel With Chromium Before Heat Treating

ONE of the peculiar problems in the heat treatment of tools, dies, cams of special shape, gages, etc. is the preservation of the surface during heat treatment. Many different methods are in use to achieve this purpose. Tools are packed in charcoal or charcoal and cast-iron chips to prevent scaling. At certain temperatures, and more especially with certain kinds of steel, this, however, causes decarburization. The tool comes out nice and clean, but has a soft skin. Salt baths are also apt to cause surface decarburization. Copper plating portions of the work where case-hardening is not desired is effective but not practical to protect work heated in an open surface, as copper is oxidized too readily. Chromium plating, however, seems to be quite effective.

Very little has been said about chromium plating prior to heat treating. For this work the question of whether the plate is gray, milky, white, or bright is of no consequence. The important things are uniformity and adherence to the plate. On irregular-shaped tools and dies the question of uniformity of plate is very closely associated with what is known as the "throwing power" of the solution. By this is meant the ability to deposit plate into depressions in the article being plated without building up too great a layer on protruding edges and points. In short, the greater the throwing power the more uniformly can an irregular-shaped article be plated.

Chromium plating is usually carried out in warm to hot solutions. This is in order to obtain a bright plate. If the solution is used cold, chromium is deposited much more rapidly and more uniformly, but a gray plate is produced. The writer conducted a series of tests to see whether a gray plate or a bright plate gave the better protection during heat treatment, also to determine how thick a layer of chromium is necessary to provide ample protection under the most adverse conditions usually found in heat treating. These tests showed: (1) The gray plate and the bright plate of equal thicknesses were about equally effective. (2) About 0.0003 in. of plate was necessary. (3) This could be deposited in 10 to 12 min. in a cold solution and in 35 to 45 min. in a hot solution. (4) The cold solution had the greater throwing power. (5) A burnt plate or too heavy a plate resulted in peeling.

In attempting to apply chromium plating to high-speed steel before heat treating, some certain interesting phenomena were brought out. Chromium-plated high-speed steel does not show "sweat" at any temperatures up to and slightly above 2400 deg. fahr. The surface appearance of the work while in the furnace therefore does not act as a guide to the hardener and notify him when to withdraw the work and quench it. Work left in the furnace too long, however, is ruined. The steel seems to liquate beneath the chromium plate, causing the plate to buckle and develop distinct wavelike lines. This condition is accompanied by a low hardness of the finished surface both as tested by the Rockwell tester and by the file test.

When a piece of high-speed steel is chromium plated and then properly hardened, that is, not oversoaked at the high temperature, the plate gives perfect protection and, aside from possible dimensional changes of the steel itself, the tool is ready for service without grinding, pickling, or mud blasting to remove the soft skin. (Sam Tour in *The Rochester Engineer*, vol. 7, no. 10, Apr., 1929, pp. 198–291, 5 figs., *p*)

VARIA

The Society of Rheology

THIS society has been organized with funds supplied by the Chemical Foundation, Inc., and will publish the *Journal of Rheology*, according to an account of the meeting of the American Chemical Society at Ohio State University, Columbus, Ohio, in the New York *Times*, May 3, 1929.

"The name of the science is derived from the Greek word meaning 'to flow,' " Dr. Bingham said. "Many people do not know that glass, cement, and iron flow as well as water. You may say, 'Here is a bridge and it does not flow, as far as I can make out.' That is true, but if the bridge fails, if it breaks, you will find that it has 'flowed' where the break occurred.

"Our fundamental object is to learn the principles that caused the break, or the flow. Presumably if the flow point could be calculated, steps might be taken to prevent the flow and the failure.

"As a matter of fact, bridges are flowing all the time. Brooklyn Bridge, for instance, is flowing, but measures were taken when it was built to accommodate this flow so that no danger would result. The flow is due, of course, to expansion and contraction.

"Knowledge of the flow of other substances would result in elimination of waste, we believe. Take, for example, clay. It is plastic, yet thousands of train loads of clay are discarded because of lack of proper plasticity. This can be remedied with proper knowledge of the principles.

"In cement roads, millions of dollars are lost because of lack of knowledge about the plasticity of the soils beneath. The elasticity of rubber cannot be measured accurately, because, when it is stretched, it never returns to precisely the same point, because it has flowed." (*The New York Times*, May 3, 1929, p. 15, *g*)

Consumption of Steel in Great Britain

THE United States with a population of 125,000,000 used last year in building and construction 50,000,000 tons of steel. On that basis England with 42,000,000 population should use about 17,000,000 tons of steel per year. Last year the total production was about 8.8 million tons, while the maximum capacity was 15,000,000 tons. In other words, slightly over 50 per cent of the maximum capacity was actually used, while at the rate of consumption of the United States the maximum capacity should have been insufficient. (Address by Sir Gilbert Vyle at the annual dinner of the Staffordshire Iron and Steel Institute, Feb. 2, 1929; abstracted through *The Iron and Coal Trades Review*, Feb. 8, 1929, vol. 118, no. 3180, p. 204, *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Screw-Thread Standards

A REORGANIZATION meeting of the Sectional Committee on the Standardization and Unification of Screw Threads was held at the A.S.M.E. headquarters on May 27, 1929. The work of this reorganized Committee will be, first, to review the finally revised report of the National Screw Thread Commission, and second, to revise and enlarge the original Committee's report published in May, 1924. This first report was approved by the American Standards Association, so this standard now enjoys the distinction of being an "American National" standard. This Sectional Committee and its predecessor were organized under the joint sponsorship of the Society of Automotive Engineers and The American Society of Mechanical Engineers.

The personnel of the reorganized committee at the time of the meeting was as follows:

R. E. FLANDERS, *Chairman*, Rep. The American Society of Mechanical Engineers
F. C. WELLS, *Vice-Chairman*, Rep. The American Society of Mechanical Engineers
EARLE BUCKINGHAM, *Secretary*, Rep. Society of Automotive Engineers
H. W. BEARCE, Rep. Bureau of Standards
C. W. BETTCHER, Rep. National Machine Tool Builders Association
H. E. BILGER, Member at Large
J. S. BLACK, Rep. American Hardware Manufacturers Association
A. BOOR, Rep. Society of Automotive Engineers
L. D. BURLINGAME, Rep. The American Society of Mechanical Engineers
G. S. CASE, Rep. Society of Automotive Engineers
T. G. CRAWFORD, Rep. National Electrical Manufacturers Association
E. H. EHRMAN, Rep. Society of Automotive Engineers
G. E. HAMMANN, Rep. U. S. Machine Screw Service Bureau
E. R. HARRIS, Rep. National Electrical Manufacturers Association
A. M. HOUSER, Rep. The American Society of Mechanical Engineers
C. V. JOHNSON, Rep. Air Corps, U. S. War Department
J. O. JOHNSON, Rep. Ordnance Department, U. S. War Department
H. C. E. MEYER, Rep. American Marine Standards Committee and Society of Naval Architects and Marine Engineers
H. G. MORGAN, Rep. American Railway Association, Signal Division
J. V. NEUBERT, Rep. American Railway Association, Engineering Division
H. D. NORTH, Rep. Cap and/or Set Screw Manufacturers Association
R. W. PAINE, Rep. U. S. Navy Department
C. M. POND, Rep. The Tap and Die Institute
H. E. SMITH, Rep. American Railway Association, Mechanical Division
C. W. SQUIER, Rep. American Electric Railway Association
H. F. TAPP, Rep. American Oil Burner Association, Inc.
D. VAN ALSTYNE, Member at Large
E. WARD, Rep. Bolt, Nut and Rivet Manufacturers Association
O. B. ZIMMERMAN, Rep. National Association of Farm Equipment Manufacturers and Society of Automotive Engineers.

In order to expedite the Sectional Committee's activities the following Sub-Committees were organized:

Sub-Committee No. 1 on "Scope, Arrangement and Editing"—R. E. Flanders, *Chairman*, L. D. Burlingame, *Vice-Chairman*
Sub-Committee No. 2 on "Terminology and Thread Specifications, Except Gages"—C. W. Bettcher, *Chairman*
Sub-Committee No. 3 on "Special Threads and Twelve-Pitch Series, Except Gages"—D. Van Alstyne, *Temporary Chairman*
Sub-Committee No. 4 on "Acme and Other Similar Threads, Except Gages"—Prof. E. Buckingham, *Temporary Chairman*
Sub-Committee No. 5 on "Screw-Thread Gages"—G. S. Case, *Temporary Chairman*.

Requests for the standardization of the threads for wood screws, track bolts, and stud bolts used in the valves and fittings industry were received and referred to Sub-Committee No. 1 for further consideration and recommendation.

Code of Minimum Requirements for the Heating and Ventilation of Buildings

THE American Society of Heating and Ventilating Engineers, New York, has just issued its Code of Minimum Requirements for the Heating and Ventilation of Buildings, which contains fourteen sections held together in a loose-leaf binder. It consists of 160 pages printed on India tint stock, 6 × 9 in. in size.

Each of the twelve sections was prepared by a sub-committee and the following subjects are covered:

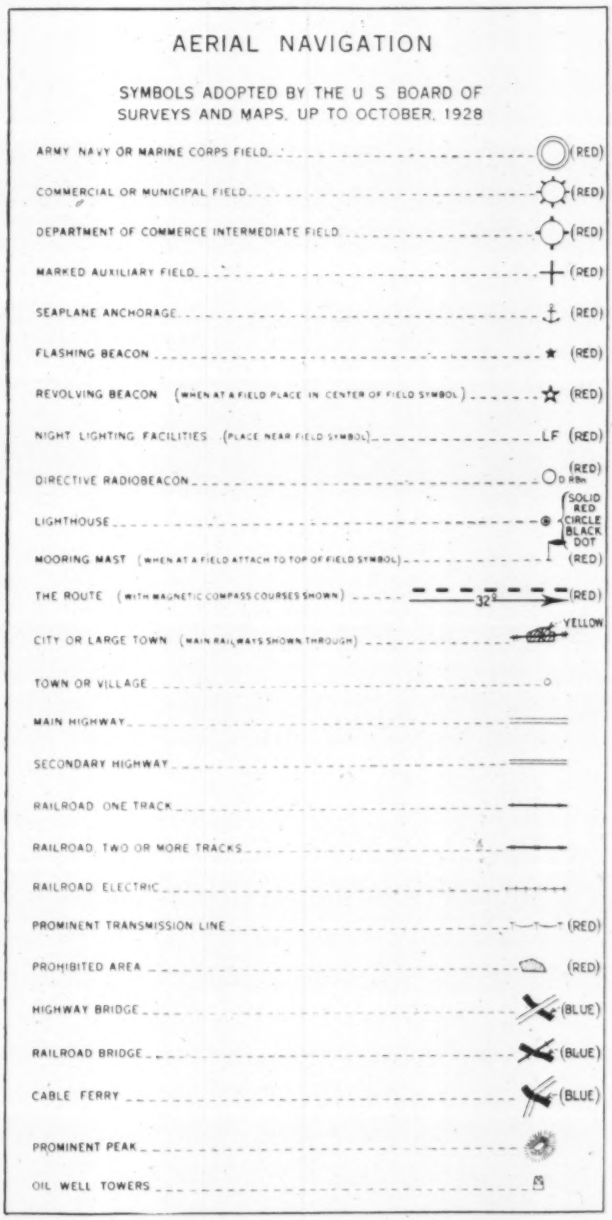
I—Minimum Ventilation Requirements for Public Buildings
II—Minimum Requirements for Estimating the Heat Required for Warm Buildings
III—Minimum Requirements for the Determination of the Amount of Direct Steam and Hot-Water Radiating Surface to Be installed in Steam and Hot-Water Heating Systems
IV—Minimum Requirements for the Determination of the Amount of Indirect Steam or Hot-Water Heating Surface to be Installed in Indirect Gravity and Fan Circulation Heating and Ventilating Systems
V—Minimum Capacity and Installation Requirements for Low-Pressure Steam and Hot-Water Heating Boilers
VI—Minimum Requirements for the Design and Installation of Warm-Air-Furnace Heating Plants
VII—Minimum Requirements for the Design and Installation of Chimneys or Stacks for Steam Boilers, Hot-Water Boilers, and Warm-Air Furnaces
VIII—Minimum Requirements for Pipe Sizes for Use with Low-Pressure Steam, Vapor, and Vacuum Heating Systems
IX—Minimum Requirements for Pipe Sizes for Use with Gravity and Forced Hot-Water Heating Systems
X—Minimum Requirements for the Design and Installation of Air Ducts, Inlets and Outlets, in Conjunction with Fan Air Circulation, and the Installation of Ventilating Fans for Use with Steam and Hot-Water Heating and Ventilating Systems
XI—Minimum Requirements for the Installation of Air Washers and Filters
XII—Pumps for Heating and Ventilation Equipment
Appendix I—Formulas for Physical Units, Air and Vapor Mixtures, Etc.
Appendix II—Standard Symbols for Heating and Ventilating Drawings.

The Code of Minimum Requirements was developed to satisfy numerous requests addressed to the society by engineers, architects, municipalities, and engineering and trade organizations, and its purpose is to standardize as far as practical the installation of heating and ventilation equipment.

The members of the Committee are: Messrs. L. A. Harding; E. Vernon Hill, Chicago; A. C. Willard, Urbana, Ill.; R. V. Frost, Norristown, Pa.; L. C. Soule, Newark, N. J.; J. F. McIntire, Detroit; J. D. Hoffman, Lafayette, Ind.; J. R. McColl, Detroit; J. A. Donnelly, Largent, W. Va.; W. S. Timmis (deceased), New York City; C. A. Booth, Buffalo; W. H. Carrier, Newark, N. J.; Perry West, Newark, N. J.; F. Paul Anderson, Lexington, Ky.; and J. H. Walker, Pittsburgh.

Scientific and Engineering Symbols and Abbreviations

THE Sectional Committee on Scientific and Engineering Symbols and Abbreviations has submitted to the sponsor bodies its fifth and sixth proposals. These cover (1) Symbols for Photometry and Illumination, and (2) Navigational and Topographical Symbols. It will be recalled that this Sectional Committee was organized in January, 1926, under


AERIAL NAVIGATION
SYMBOLS ADOPTED BY THE U S BOARD OF SURVEYS AND MAPS, UP TO OCTOBER, 1928
ARMY, NAVY OR MARINE CORPS FIELD (RED)
COMMERCIAL OR MUNICIPAL FIELD (RED)
DEPARTMENT OF COMMERCE INTERMEDIATE FIELD (RED)
MARKED AUXILIARY FIELD (RED)
SEAPLANE ANCHORAGE (RED)
FLASHING BEACON (RED)
REVOLVING BEACON (WHEN AT A FIELD PLACE IN CENTER OF FIELD SYMBOL) (RED)
NIGHT LIGHTING FACILITIES (PLACE NEAR FIELD SYMBOL) LF (RED)
DIRECTIVE RADIOBEACON (RED) R Bn
LIGHTHOUSE SOLID RED CIRCLE BLACK DOT
MOORING MAST (WHEN AT A FIELD ATTACH TO TOP OF FIELD SYMBOL) (RED)
THE ROUTE (WITH MAGNETIC COMPASS COURSES SHOWN) 32° (RED)
CITY OR LARGE TOWN (MAIN RAILWAYS SHOWN THROUGH) YELLOW
TOWN OR VILLAGE
MAIN HIGHWAY
SECONDARY HIGHWAY
RAILROAD ONE TRACK
RAILROAD TWO OR MORE TRACKS
RAILROAD ELECTRIC
PROMINENT TRANSMISSION LINE (RED)
PROHIBITED AREA (RED)
HIGHWAY BRIDGE (BLUE)
RAILROAD BRIDGE (BLUE)
CABLE FERRY (BLUE)
PROMINENT PEAK
OIL WELL TOWERS

the procedure of the American Standards Association with the A.A.A.S., A.S.C.E., A.I.E.E., S.P.E.E., and the A.S.M.E. as joint sponsors. Twenty-nine national societies and associations have appointed official representatives on the Sectional Committee, of which Dr. J. Franklin Meyer is Chairman, Sanford A. Moss, Vice-Chairman, and Preston S. Millar, Secretary.

SYMBOLS FOR PHOTOMETRY AND ILLUMINATION

The Symbols for Photometry and Illumination were prepared by Sub-Committee No. 4, the personnel of which is: E. C. Crittenden, Chairman, Bureau of Standards; Frank Benford, General Electric Co.; R. S. Burnap, Edison Lamp Works of General Electric Co.; W. E. Forsythe, National Lamp Works of General Electric Company; D. R. Grandy, Cooper-Hewitt Electric Co.; L. A. Hawkins, General Electric Company; G. A. Hoadley, Swarthmore College; A. E. Kennelly, Harvard University; M. Luckiesh, National Lamp Works of General Electric Company; C. O. Mailloux, Consulting Engineer; A. S. McAllister, Bureau of Standards; W. J. Serrill, American Standards Association, C. H. Sharp, International Commission on Illumination; G. H. Stickney, Edison Lamp Works of General Electric Company; and A. G. Worthing, University of Pittsburgh.

This list of symbols constitutes a revision of the symbols contained in the "Illuminating Engineering Nomenclature and Photometric Standards," adopted in 1925 as an American Standard under the procedure of the American Standards Association. The proposed standard now presented was distributed for criticism and comment in December, 1928. The suggestions received were considered by the Sub-Committee and the proposal was sent to letter ballot of the Sectional Committee in February, 1929. Having been accepted by the Sectional Committee, this proposed standard is now before the five sponsor bodies for approval with the recommendation that it be submitted to the American Standards Association for approval and designation as an American Standard. The symbols in question are reproduced below, and all who are especially interested in this subject may secure a copy of them from C. B. LePage, Secretary of the A.S.M.E. Standardization Committee, 29 West 39th Street, New York, N. Y. It is requested that criticisms or comments on this proposal be sent to the same address.

Symbols for Photometry and Illumination

Quantity	Symbol
Radiant flux	Φ
Luminous flux	F
Luminous intensity (candlepower)	I
Illumination	E
Quantity of light	Q
Brightness	B
Visibility factor	K
Reflection factor	ρ
Absorption factor	α
Transmission factor	τ
Mean spherical candlepower	I_s
Mean lower hemispherical candlepower	I_l
Mean upper hemispherical candlepower	I_u
Mean zonal candlepower	I_z
Mean horizontal candlepower	I_h

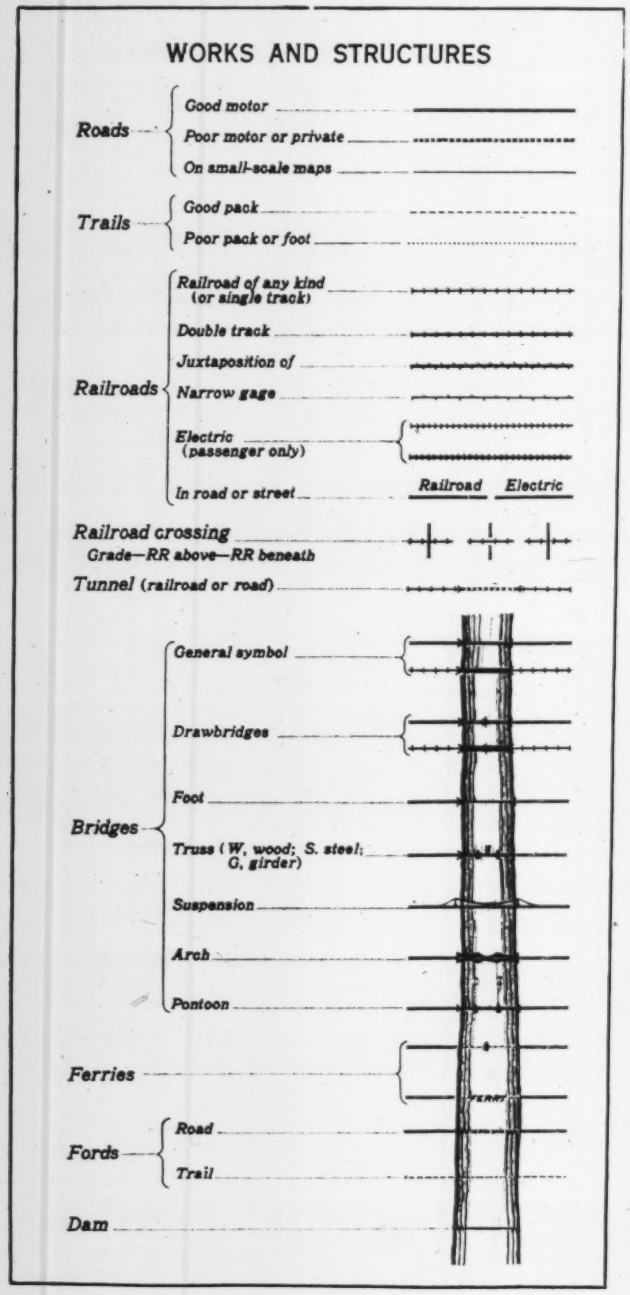
NAVIGATIONAL AND TOPOGRAPHICAL SYMBOLS

Sub-Committee No. 8 on Navigational and Topographical Symbols has also just completed its report, having submitted the proposed set of symbols for criticism in January, 1929. As a result of the comments received, the Sub-Committee revised its proposal in certain minor particulars. The revised proposal was sent on February 16, 1929, to letter ballot of the Sectional Committee. A favorable vote was received and the Sectional Committee has submitted these symbols to the sponsor bodies with the recommendation that they be approved as an American Tentative Standard. The personnel of Sub-Committee No. 8

is as follows: George L. Hosmer, Chairman, Massachusetts Institute of Technology; Dabney O. Elliott, Engineers Corps, U. S. Army; Charles M. Spofford, Massachusetts Institute of Technology.

EXPLANATORY NOTES

1 The Committee recommends that for use on small-scale maps



all symbols shown on the chart entitled, "Standard Symbols adopted by the Board of Surveys and Maps, United States of America," edition of 1925, be adopted except as follows: that the symbols for Aerial Navigation be superseded by those adopted by that Board in 1928; and that the abbreviations[1] for use on military maps be omitted.

[1] This refers to the abbreviations only, not to the symbols.

2 It is recommended that for large-scale plans all symbols on the 1925 chart mentioned above which properly apply to such plans be adopted, and in addition thereto the symbols for transit station (circle with central dot) and for stadia station or plane-table station (square with central dot).

3 The following statement regarding miscellaneous information to be shown on maps and plans is also recommended for adoption. All maps and plans should show clearly:

a The scale, both the representative fraction (R.F.) or its equivalent, and a graphical scale (except for such projections as have a variable scale)
b The direction of the true meridian, or the direction of the magnetic meridian together with the magnetic declination
c The general location of the map, either by meridians and parallels, or by one or more points known in position and located either by latitude and longitude or by coordinates referred to some established point
d The datum for elevations (if elevations are shown on the plan)
e The contour interval (if contour lines are shown on the plan)
f The control (triangulation or traverse, and levels)
g The kind of projection used, if meridians and parallels are shown on the plan
h Names of the authors or surveyors responsible for the map
i The dates of the survey and of publication
j Details of map by (transit and tape, transit and stadia, or plane-table and stadia) method.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 621, 623, and 624, as formulated at the meeting of April 19, 1929, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 623

Inquiry: Is it permissible for safety valves set at 15 lb. on a boiler built according to the Power Boiler Section of the Code, to use discharge capacities stamped on the valves by the manufacturers, the stamping being the discharge capacity at 20 lb. relieving pressure, the high-lift valves to have greater capacity than given in Table H-6, the number of such valves to be de-

termined by the maximum weight of steam which the boiler is capable of generating?

Reply: If the boiler is to be used in accordance with the provisions of Par. H-1*a* of the Heating Boiler Section of the Code, Par. H-53 applies. This paragraph is specific in its requirements that the minimum safety valve relieving capacity for steam heating boilers shall be based on the grate area of the boiler.

CASE NO. 624

Inquiry: Is it the intent of Par. P-218 of the Code, that permits of reduction by 100 sq. in. of the area of the front head below the tubes of an h.r.t. boiler that is required to be stayed, that a corresponding reduction of area is permissible in the portion of the rear head below the tubes?

Reply: The exemption of 100 sq. in. in the area of the front head of an h.r.t. boiler below the tubes was intended to permit of simplification of the staying requirements around the restricted area of the manhole. This exemption does not apply to a head without a manhole as provided in Par. P-218.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Wages of Engineers

TO THE EDITOR:

In the April issue of MECHANICAL ENGINEERING on page 319, Thomas H. Normile commented on an article in the December, 1928, issue, by Crosby Field, on the engineer, his wage-earning capacity, and his place as resident and professional consultant.

Mr. Field's figures, which show the percentages of the men engaged in the professions of medicine, law, architecture, and engineering who are working for themselves to be 70 per cent in the first, 71 per cent in the second, and nine per cent in the third and fourth, are very interesting, but the writer cannot quite agree that the conditions in medicine and law are analogous to those which apply to the engineer.

In the first place, the demands upon the experience of an engineer are far more severe than they are upon members of the medical and legal professions. As an example let us take three young men who have completed their training, respectively, in medicine, law, and engineering. The first, after completion of his internship, is ready to hang up his shingle. The second, after completion of his studies and serving a short clerkship, if he has a large acquaintance can immediately start in practice; if not, he associates himself with some representative firm of attorneys and in a year or two starts out for himself. In the third case the engineer, after completion of his studies, first begins to apply his theory to practice. He is obliged to subordinate everything in the way of emolument to the primary consideration of obtaining practical experience in the field. No one would think of engaging a young and inexperienced engineer in an independent manner for either consultation or specific work.

The physician or attorney is not asked to give proof of his experience. It is usually a case of knowing something about the man and reposing confidence in him. If either makes a fatal mistake in the performance of his service to his patient or client there is little or nothing that either patient or client can do about it. On the other hand, the engineer who considers entering practice must not only be in a position to show what he has accomplished, but must further realize that he will never be forgiven for the mistakes he makes.

We are told that it is possible the engineer may lack "personality" in "putting himself across." The writer sincerely believes that this has nothing to do with his case. He is prepared to concede that engineers as a whole are not of the glib or high-pressure types, but all in all they are a hardy lot after a homely fashion, which as often as not supplements what they may be lacking in so-called "personality."

The writer would like further to observe that medical and legal students from the very outset carry along with their studies a business aspect concurrent with their respective professions. It is part of the classroom discussion that "your patient should be handled so and so;" "your client should be advised so and so." There is no such psychology back of the engineer's training. He begins and completes his education as a technician. Any other viewpoint is seldom if ever taken in or out of the classroom.

If the young engineer does hazard to think in terms of his own practice, it always seems in the far distance and something to which he frequently hopes to retire rather than begin with.

It seems to the writer that a great deal could be done if we were to begin right at our schools and universities in the early training periods of our engineers and inculcate an understanding similar to that which the medical and legal students receive.

While opportunities for the engineer are not as readily attainable as for the physician or the attorney, classroom discussion will help him materially if he begins with the point of view that his profession does not necessarily seek to fix him as a resident technician.

As a point of interest there are a number of young engineers whom the writer has placed from time to time in such industries as food products, clothing, candy, textiles, paper novelties, furniture, bookbinding, printing, motion pictures, etc. Almost without exception these young men have made good. Some have started in minor executive and technical capacities and worked themselves up to participating interests or responsible executive and technical positions. They were placed in these industries with the object of applying engineering principles to the economics of production and control, of development in methods and processes, and the like.

There are a great many industries in our country today which employ few if any engineers, but which offer tremendous opportunities for utilizing their training and abilities. Take, for example, one of the largest industries in our country, the manufacture of clothing. It produces merchandise to the value of one and three-quarters billions of dollars a year and employs approximately a quarter of a million people, yet to the writer's definite knowledge there are fewer than five engineers engaged in this industry who specifically devote their time to work which is within the scope of their particular training.

There seems to be an idea that an engineer's place in industry is primarily concerned with the machinery and equipment which it requires, develops, and utilizes, to the almost complete exclusion of the broader aspects concerned with the economics of production and distribution. The writer believes that if we give a little of our attention to this latter phase of the engineer's place in commerce and industry, we shall materially increase the numbers of opportunities for the engineer.

M. E. POPKIN.[1]

New York, N. Y.

[1] Consulting Engineer, Assoc-Mem. A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Applied Mechanics

Deformation of Aluminum Sheet

AM-3 A 41-in. by 54-in. by 0.029-in.-thick aluminum sheet is bent around a 24-in.-diameter roll, the 41-in. dimension passing around the cylinder. What is the effect on each of the two surfaces of the sheet, and how much does each change from its original dimension?

There are many different ways of bending sheets around a cylinder and quite a number of different grades and tempers of aluminum that may be used, and each presents a problem in itself. It is furthermore realized that most of the methods of bending a sheet around a cylinder subject the sheet to external restraint, such as friction between the sheet and the cylinder, which usually makes the problem too complex to allow complete analysis. One study of the problem follows but, as will be noted, this analysis is based upon certain conditions which are not ordinarily obtained in practice; yet it would seem to be a sensible approach to the problem.

When a sheet is bent around a cylinder, the inner surface will become shorter, the outer surface will become longer, and no change in length will take place along the neutral axis of the sheet, the latter being located about midway between the inner and outer surfaces of the sheet. Test data indicate that Young's modulus, usually called the modulus of elasticity, for aluminum and most aluminum alloys is 10,000,000 lb. per sq. in., both in tension and in compression. Assuming in our problem, therefore, that the modulus of elasticity is equal in tension and in compression, the neutral axis should be midway between the inner and outer surfaces; hence the amount that the inner surface becomes shortened will be equal to the amount that the outer surface becomes lengthened. This is based upon the assumption that the material is homogeneous throughout, that it is free from internal strain, and that it behaves in accordance with Hooke's law.

Let us assume that a sheet 0.029 in. thick is bent around a 24-in.-diameter roll and that this sheet has sufficient length to reach the entire distance around the roll. The length of the inner surface of the sheet will be 75.3982 in., corresponding to a 24-in.-diameter circle. The length of the outer surface of the sheet will be 75.5804 in., corresponding to a 24.058-in.-diameter circle. The length of the neutral axis of the sheet will be 75.4893 in., corresponding to a 24.029-in.-diameter circle. By subtraction we find that the inner surface of the sheet is 0.0911 in. shorter and that the outer surface of the sheet is 0.0911 in. longer than the original length of the sheet, assuming that the original length corresponds to the length of the neutral axis. If we then divide this total change in length of the surface, 0.0911 in., by the length on the neutral axis, 75,4893 in., we obtain 0.00120 in. per in., which is the unit deformation on each surface of the sheet. In this particular problem a sheet only 41 in. long has been bent around the roll; therefore the change in length of surface of this sheet will be the product of 41 times 0.00120, giving a value of 0.0494 in. This latter value is the increase in length of the outer surface and the decrease in length of the inner surface of a sheet 41 in. long $\times$ 0.029 in. thick when bent around a 24-in.-diameter roll. (C. L. Eksergian, Research and Development Engineer, Budd Mfg. Co. and Budd Wheel Co., Philadelphia, Pa.)

Fuels

Boiler-Tube Failures[1]

F-9 What specific instances can be quoted when using distilled-water make-up, of the blistering or failure of boiler tubes directly exposed to the radiant heat of the furnace? Instances are desired either on the first two rows of boiler tubes, on the water walls, or on water screens, either with stoker, pulverized-fuel, or oil firing. Quote circumstances and method of eventual solution.

In answering the above question, it is assumed that the phrase "when using distilled-water make-up" implies that evaporator make-up constitutes a large percentage of the total make-up, as there is always the possibility that a certain amount of raw water is used in the average plant.

The writer cites the following case where the bottom row of tubes in each of two boilers was removed twice within a year. The boilers were of the B. & W. cross-drum type, operating at 385 lb. pressure, 27 by 20 tubes high, having a Webster baffle, burning 14 deg. B. fuel oil, with 6880 cu. ft. of combustion space, and the maximum rating was approximately 100,000 lb. of steam per boiler per hour.

The boilers were first put into operation February 20, 1926, and a leak developed in a tube in the bottom row on October 10, 1926. On examination it was found that the tubes of the entire bottom row in each boiler were burned, making renewal necessary. During this period each boiler operated approximately 3100 hours. The total make-up was approximately 5 per cent, of which 1.38 per cent was raw water, the remainder being from the evaporators.

On the assumption that most of the trouble was due to the use of raw water, particular pains were taken to reduce the raw-water

[1] This subject has been discussed in a previous issue.

make-up to a minimum, and after the tubes were renewed, the boilers were back in operation October 15, 1926. On January 2, 1927, leaks developed in the bottom row of tubes and it was again found necessary to renew the complete row in each boiler. During the period from October 15, 1926, to January 2, 1927, each boiler operated approximately 1600 hours, and while the total make-up remained about the same, that is, about 5 per cent, the raw-water make-up in this case was only 0.25 per cent.

Analyses of the scale removed from the tubes on October 10 and on January 2 are given below:

	Oct. 10	Jan. 2
Calcium silicate, per cent	15.50	14.16
Calcium sulphate, per cent	11.39	9.86
Iron oxide, per cent	70.53	73.78

The general character of the raw water was as follows:

Total solids	Per cent
Silica and insoluble	0.82
Iron and alumina oxides	0.20
Calcium sulphate	1.70
Calcium carbonate	0.66
Magnesium carbonate	0.13
Sodium chloride	1.15

Inspecting the foregoing, it was found that the amount of iron oxide present in the scale indicated oxygen corrosion in the boilers, and this was found to be the case. Necessary steps were taken to reduce the amount of oxygen in the feedwater to a minimum, and treatment to maintain a certain alkalinity of the water was initiated.

Since January, 1927, no further trouble has been experienced, no scale being present in the boilers and, on frequent examinations, no further evidence of corrosion has been found. (M. H. C., Bay Shore, N. Y.)

Railroad

FOUR TRUCK AXLES IN ENGINES WITH THREE DRIVING AXLES

R-3 How can we justify four truck axles when used in the same engine with three driving axles?

The writer assumes that the question refers to the 4-6-4 type of locomotive, also known as the Hudson type. This type of locomotive has a 2-axle leading truck, 3 driving axles, and a 2-axle trailing truck.

This type of locomotive is intended for use in heavy, high-speed passenger-train operation, and for this service a 2-axle leading truck is necessary because of its very superior guiding characteristics.

The most important characteristics of a locomotive for use in heavy, high-speed service are (1) high sustained cylinder horsepower and (2) high sustained steam-generating capacity. The second characteristic can be obtained best by the use of a very large firebox in the boiler for the following reasons: (1) The firebox can be built so as to produce very rapid ebullition of steam; (2) the larger the firebox, the more effectively can complete combustion of the coal gases be obtained; (3) the larger the firebox, the more completely can the radiant heat released in the firebox be absorbed by the water in the boiler. A very large firebox requires a 2-axle trailing truck to support it. It may be argued that this extra weight should be supported by a driving axle. However, it would be impractical to mount a wide, deep firebox above a driving axle and between a pair of driving wheels. Furthermore, the weight of such a firebox, supported by a driving axle, would be useful for adhesion only at slow speeds when the maximum tractive effort of the locomotive is required. At all other times the extra driving axle would be functioning at less than capacity and would thus be adding, needlessly, to the maintenance costs of the locomotive. The weight of the firebox can be used for adhesion at low speeds by applying a booster to the trailing-truck axle. (R. P. Kolb, Assistant Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C.)

Miscellaneous

USES FOR WASTE GYPSUM

M-6 For what purposes is the waste gypsum collected from the tables in plate-glass manufacturing plants used?

At the present time the writer's company is making no use of waste plaster but is simply getting rid of it in the least costly and most convenient manner. At one time part of this waste was calcined and mixed with new plaster and used in a limited way for laying glass. Later the calcined waste was mixed with a proportion of new plaster and wood fiber and sold as a wall plaster. Attempts have also been made to use it in the manufacture of plaster board. Another use which has received some attention is for agricultural purposes.

None of the foregoing uses has been continued as they were not found profitable.

Considerable experimental work has been carried out with the object of making it suitable for reuse, but so far the writer's company has not found a process which is commercially practical, nor has it been able to produce from the waste a plaster which is satisfactory. In every case the product lacks density.

This company's experience indicates that the reclaiming of waste plaster results in loss of original density, and repeated reclamation gives further deterioration in density. The strongest and most satisfactory plaster is one which is sufficiently fine in particle size and possesses the maximum density; that is, assuming it has been properly calcined. A comparison of new and reclaimed plaster tests follows:

Recalcined plaster regains to a considerable extent its former properties—roughly it may be said to be 80 per cent as good as new. The sieve test shows the recalcined to be finer than the new. The time of set by the penetration test is the same. The temperature developed in setting by reclaimed plaster is 87 per cent of that developed by new plaster, even though the rate of heat development is 50 per cent faster. A comparison of tensile strength was as follows:

	1 Day	7 Days	28 Days
New	143 lb.	232 lb.	256 lb.
Recalcined	127 lb.	208 lb.	207 lb.

According to the above tests one might believe that reclaimed plaster could be used satisfactorily for relaying glass; however, experience shows that it is not dependable—it lacks holding power and weakens during the process of grinding and polishing. This behavior is very similar to that encountered when using new plaster which has not been properly calcined or prepared. A plaster which heats up rapidly in a setting test is generally unsatisfactory in use.

Waste plaster from the grinding and polishing of glass is not a very attractive material to handle as it contains over 50 per cent of water, and the differential between cost of new material and cost of reclamation by drying and calcining makes the problem still less attractive. The writer's company feels that the effort should be to find some other use for this material. (F. Gellstharp, Director & Chief Chemist, Research Laboratory, Pittsburgh Plate Glass Co., Creighton, Pa.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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Wage Incentives

STRAIGHT piece-work and time wages are obvious and simple plans for paying workers, but like many simple and obvious plans they are inadequate and unsatisfactory in a majority of cases in modern industrial life. The philosophers of modern management were quick to recognize the unsatisfactory elements of these systems and attempted improvements of them. Thus Taylor, Gantt, Halsey, Emerson, and numbers of others devised systems of wage payment which were designed to correct the bad features of time and piece-work wages.

As a leading article in this issue Charles W. Lytle discusses a phase of the wage-payment problem which has engaged the minds of many industrialists and engineers—that of financial incentives. The discussion which he presents is summarized from his forthcoming book on wage payment, to be published by the Ronald Press at an early date.

The value of the contribution which Mr. Lytle has made lies in the comparison of the essential characteristics of various plans. Most of these plans are well known; most of them are in use in some plant. Few persons, however, are familiar with all of them or recognize their essential differences. In bringing attention to focus on principles involved in wage-incentive plans and in discussing their characteristics Mr. Lytle has greatly benefited every one who is faced with the problem of wage payment.

Engineering Revealed

IN THE scintillating kaleidoscope of American economic life today, the report of the Committee on Recent Economic Changes discovers a plan, an economic balance, a dynamic equilibrium, the maintenance of which involves a problem of leadership demanding public attention and a general knowledge of the interrelations of the vital influences that shape our life. To engineers this report and the comprehensive investigations on which it is based indicate that engineering has at last been revealed as a powerful means of improving the general public well-being. Increased pace and broadened effect are the two important items that characterize the last few years' developments. The engineering profession has contributed in large measure and due credit is given it in this report, first, by the inclusion of engineers in the list of authors, and second, by a frank discussion of the contributions of engineering to economic changes.

As engineers receive recognition as a moving force in modern life, they must assume commensurate responsibility. This responsibility includes a knowledge of the implied economic consequences arising from the engineering changes in civilization. The engineer who wants to build up a thorough background of economic thinking will enjoy reading this report, and will be fascinated by the investigations on which the report is based.

The report is printed in full in this issue of MECHANICAL ENGINEERING. The investigations on which it is based are embodied in a two-volume book.

Absolute Zero

THE announcement that the absolute zero of temperature has been approached to within a single degree tells of a victory which has been in sight for a very long time. One by one the frontiers of the physical properties of materials are beginning to fall. In the Benson boiler use is made of a water and steam mixture at the critical pressure and temperature where water turns into steam without boiling, without liberating or consuming latent heat, and without changing in volume.

At absolute zero temperature there is of course no flow of heat from the material because, according to the second law of thermodynamics, heat can flow only from a hotter body to a colder one, and there can be no "colder" body than one having zero temperature. Metals appear to lose entirely their ability to resist the flow of electric current, and to become perfect conductors.

Of course, great as it is, it should be remembered that the attainment of the absolute zero temperature is one of the easier steps in the conquest of frontier properties of physical bodies. It is like climbing Pike's Peak as a preliminary to attempting the ascent of Mt. Everest. The physicist has still many worlds to conquer. He has attained the lowest temperature and is in sight of —273 deg. cent., but when he tries to look up to the highest temperature a very dazzling altitude meets his eye. We know already that the temperature of matter in the interior of the sun is of the order of 40,000,000 deg. cent., and it would not be surprising if this were the topmost temperature occurring in the stellar agglomerations of matter, even though we know of no reason why it could not be exceeded.

In the realm of speed we are somewhat better off. It is true that bodies propelled by human agencies fly at pitifully low speeds, barely exceeding those of sound, but we know light, or at least if we do not know what it is, we know it when we see it. From all indications it would appear that the velocity of light is the highest velocity that is actually attained in the universe, although here again we know of no reason why a greater velocity should not be possible.

Fitzgerald was the first to show that a body moving in a certain direction contracts in that direction, the contraction depending on the velocity of the motion of the body. The earth from the point of view of the Fitzgerald coefficient of contraction is a slow-going vehicle and its speed produces a contraction only of the order of one two hundred millionth. Nevertheless it should be clearly understood that when we draw a circle on paper it is slightly out of true because of this factor. If we could manage to hitch on to a light wave, the Fitzgerald coefficient of contraction

would become so great as to reduce the dimension of a body in the direction of motion to zero. In other words, if we attempted to carry with us a nickel to pay the fare, that nickel while we were riding on a light wave would retain its diameter crosswise to the direction of motion but would become a mere geometrical line in the direction of motion, and it would probably be refused in payment of a fare by any representative of the Light-Wave-Speed Public Utility Company.

It is very significant, now that we have achieved an approach to the absolute zero of temperature, that we have merely found a confirmation of things which we knew would happen long before we actually made it possible for them to happen. But if we ever reach the absolute maximum of temperature or speed or pressure, most likely we shall merely introduce a correction in the seventh decimal of our formulas already determining what happens at these absolute maxima.

The Cleveland Hospital Disaster

CARELESSNESS and lack of system were disclosed at nearly every step in the investigation of the Cleveland hospital disaster. Safety precautions that are now recognized as most essential in buildings where many people congregate, were ignored. In the first place, some 7000 lb. of nitrocellulose films were stored in a room to which, apparently, all classes of people had access. Steam fitters, workmen, and attendants passed in and out without warning. This explosive, equivalent to $3^1/_2$ tons of smokeless powder but much less stable in its characteristics, was in a room which had safety doors that had not operated for years. Evidently no one realized that safety doors to a room containing several tons of high explosives were intended to close.

Wiring and connections for electric light were most crude. When more light was needed at a particular location an extension cord with a bare bulb was installed, and no precautions were taken to prevent an accumulation of static electricity. Warning signs and danger signals prohibiting smoking or the carrying of open lights or matches were not displayed, and the presence of this enormous amount of explosives seemed to be ignored.

Lackadaisical attitudes of this kind are responsible for many of the greatest disasters. The storage of X-ray films in the Cleveland hospital, the overcrowding of the steamship *Vestris*, the carrying of poison gases through the streets of Hamburg without proper precautions, are a few instances where loss of life and property have occurred that could have been prevented with but little trouble. Precautionary measures consist in applying proper engineering principles and in placing all engineering activities of public institutions under the responsible supervision of properly qualified persons. A safety inspection engineer would not fail to see the menace of a heavy steel door that does not close. He would want to know why, and would find out what the room contained that made it necessary to have steel doors, and he certainly would not tolerate storage in a hospital of thousands of pounds of highly explosive material without protest.

A feature of the Cleveland disaster was the tremendously high toxicity of the gases developed. Neither carbon monoxide nor nitrogen peroxide alone or in combination constitutes a poison that will kill instantly when present in such concentrations as can be obtained in the open air.

It was probably the presence of bromine, or more likely its compounds, that was responsible for the death of those breathing the gases. There is nothing strange about the origin of this bromine. The sensitive material of photographic films contains a large amount of silver bromide, which, under high temperatures, will develop fumes of a bromine compound, and in the presence of cellulose burning at a high temperature may have produced pure bromine gas.

The Broadened Outlook of Engineering

A GENERATION ago a somewhat jocose definition of the three groups of engineering then existing was current. According to that definition a mechanical engineer knew nothing about electricity, an electrical engineer knew nothing about mechanical construction, and a civil engineer was secure in his ignorance of both electricity and mechanism. The engineer of those days was a narrow specialist, knowing little about other branches of his profession and somewhat contemptuous of the work of such "highbrows" as physicists and chemists.

It is remarkable how things have changed in a single generation. The electrical engineer by the very character of his work was the first to be forced into contact with the realm of higher physics. Electrodeposition was one of the earliest developments that brought him in close touch with physical chemistry and taught him the value of looking after such things as ion concentration. The modern radio would have been entirely impossible without the three-element tube, the working of which depends entirely on the flow of electrons. Now comes the photoelectric cell, which involves a still higher application of physical principles.

The metallurgist, who dealt formerly with such tangible actualities as temperatures and chemical analyses, has cleared in one jump the distance from mere microscropic observation to such apparently imponderable theory as that of the atomic structure, and after talking of body-centered and face-centered crystals, is now beginning to break into the subatomic phenomena.

The mining engineer has not escaped from the same necessity of going far beyond what only a short time ago appeared to be the legitimate bounds of his profession. There was a time when the mining engineer looked for oil by gravely considering such things as shifts, inclines, etc. Outcroppings were given serious consideration, and once in a while even vegetation was taken into account in a half-ashamed way. There were not lacking cases where even the divining rod was used—mostly unofficially, and not to be mentioned if it did not lead to success. Finally, just as frequently all of these scientific trappings were brushed aside by the fellow who played a "hunch," wildcatted, and once in a while found what he was after. Among mining engineers there accordingly developed the incontrovertible maxim that "gold or oil is always where you find it." How different this is from the mining engineer of today, who has already gone a long way toward learning to find his minerals not by guess but by actually locating them through the geophone, by the Eötvös balance, by observing the travel of sound through the earth's crust, and by measuring the resistance of that crust to the propagation of radio waves. Here are several branches of advanced physics and electricity employed in an engineering art where formerly the main tools were a pick and shovel and a long-eared burro.

The mechanical engineer has likewise jumped out or been jolted out of the narrow bounds of what he formerly considered his profession. A very significant instance of this is given in a recent editorial in *Engineering*, in which the design of steam turbines is considered from the point of view of creep of materials. In discussing his subject, the writer, among other things, brings in such striking factors as the behavior of astronomical clocks and the geologic formation of the Laurentian Mountains. It certainly is a broadened outlook which takes into consideration sciences and arts apparently entirely unrelated to the subject under immediate consideration.

Aerodynamics, a science which was non-existent only twenty-five years ago, is already becoming an important branch of engineering and its results are being translated into elements of design of steam-turbine blades, locomotives, rifle bullets, and the like. Negative catalysis, a part of a branch of chemistry which has barely attained its majority, now lies at the foundation of the

work of preparing fuels for high-compression engines, while the mechanical engineer who wants to know about coal and its modern derivatives has to consider a vast number of subjects ranging from catalytic hydrogenation and the colloidal suspension of fine coal in air and liquids down to such by-products of coal as tars, soaps, dyes, and explosives. A German navigation company has for its motto, "The world is my field," and modern engineering is practicing that gospel.

Broken Wires in Suspension-Bridge Cables

REPRESENTING as they do the first serious failures of bridge-suspension systems in modern times, the cable-wire breakages of the Mount Hope and Ambassador suspension bridges are of particular interest to all classes of engineers. Full research into the behavior of heat-treated steel wire is urgent. A large number of samples of the damaged cables are being examined and tested by the Bureau of Standards, Washington, D. C., and reliable data from which to draw conclusions will receive close attention from metallurgists and engineers. The most likely solution of the perplexing problem should come from a careful comparison of differences in manufacture of cold-drawn and heat-treated wire, differences in the erection practices employed, the susceptibility of wire to pickling and galvanizing troubles, and the behavior of heat-treated wire under slowly increasing loads.

The records of manufacture of the wire and construction of the bridges show several departures from usual practice. Both bridges were constructed of the same type of wire, which was radically different from the cable wire of previous suspension bridges. After the drawing operation, the wire was hardened by heating in a lead bath and quenching in oil. It was then galvanized in a bath of molten zinc. The usual laboratory and acceptance tests showed the wire to be as good as cold-drawn wire.

The method used for spinning the cables was different from that commonly used. The spinning was done directly in the permanent saddles instead of in temporary saddles from which the completed strands must be hoisted into place. Anchorage eyebars were installed in a flat position instead of vertically as in previous construction. This eliminated the necessity of turning the shoes 90 deg. to attach them to the eyebars. To provide a good fit for the wires as they passed around the strand shoe, they were preformed by bending around a sheave of small diameter.

The Ambassador bridge has a 1800-ft. span to connect Detroit with Windsor, Ontario. The Mount Hope bridge has a 1200-ft. span to carry a highway between Providence and Newport, R. I. The cables for the latter bridge are 11 in. in diameter, each composed of seven strands having at least 350 No. 6 wires. The first indication of failure was the discovery of three broken wires at one of the strand shoes of the Mount Hope bridge in January of this year, after the steelwork had been erected and the concrete roadway started. The number of broken wires continued to increase until, at the end of March, work was stopped, when careful analysis of one strand showed 75 per cent of the wires were broken.

The majority of the breaks occurred in two strands. In the east cable the breaks were at the Bristol anchorage near the tangent point of the strand shoe; 75 per cent of the total number of wires in the strand were broken. In the west cable, 130 wires out of a total of 180 in a half-strand were broken. The breaks in the west cable were at the Portsmouth anchorage, also near the tangent point.

The breakage of wires appears to have increased progressively. Nothing resembling a time effect of loading has been found previously in such construction, even at full working stress. At the time the breakage occurred the stress in the cables was very low.

Entrance of the Bureau of Standards into the investigation is to be commended. Experts in the various phases of wire production should lend their aid and knowledge in solving this problem which is so important to the science of suspension-bridge building.

The "Spirit of St. Louis" Aeronautical Medal

ONE of the pleasant features of the Third National Aeronautic Meeting held at St. Louis, Mo., May 27 to 30, was the presentation to Daniel Guggenheim of the "Spirit of St. Louis" Aeronautical Medal for his meritorious service in the advancement of aeronautics.

The medal was established by an endowment created by citizens of St. Louis and donated to the A.S.M.E. It will be presented every three years to a person nominated to the Council of the Society by a special committee of the Aeronautic Division through the Committee of Awards.

Daniel Guggenheim's services to aeronautics are well known. In 1925 he contributed $500,000 for a school of aeronautics in New York University. The following year, with a sum of $2,500,000, he established the Daniel Guggenheim Fund for the Promotion of Aeronautics. In 1927 he contributed $25,000 for the search for the lost French aviators, Nungesser and Coli, and in 1928 a sum of $500,000 to the Chilean Government for a school of aeronautics in Chile. In conferring the "Spirit of St. Louis" Medal upon Mr. Guggenheim the Society has recognized an unselfish service intelligently rendered.

An Industry Leading the Way

FOR a joint meeting of the Management and Materials Handling Divisions of the A.S.M.E., Detroit, with its automobile industries, proved to be an appropriate location. Here for three days, May 1 to 3, members of these two divisions, with guests from all parts of the country, met for a program of well-coordinated papers and a series of plant inspections that were enthusiastically attended.

It was impressively shown at the meeting that the conveyor method is remarkably adaptable, and that revolutionary changes in old and established industries have been necessary in order to secure the economy of the new methods. Changes in business conditions have made it necessary, for instance, to budget very carefully production and purchases. So-called "hand-to-mouth" buying, which appears to have become an essential element of modern business, calls for the most painstaking planning and intelligent coordination of all departments of the plant, and all agencies that serve it. As one motor-car manufacturer put it, the freight service of some of the railroads is so dependable that the railroad can really be considered a part of the conveyor system of the plant.

Evidence is abundant that the economies effected in the automobile industry as illustrated at the Detroit meeting are also to be made in other industries which are adapted to similar methods of management and production.

Keen interest in the program proved the value of the meeting to those in the industry and to those who could apply some of the methods described and illustrated in other fields of production. The enthusiastic two hundred who rose every morning at an early hour in order to visit the plants profited by the generous hospitality of the local industries. Detroit has won for itself the appreciative gratitude of many engineers who look to the automobile industry as developing principles in management and materials handling which are frequently applicable to other production problems.

The A.S.M.E. Meeting at Rochester

Notes on Some of the Outstanding Features of the Technical Program

A VARIED program of technical papers such as that presented at the meeting of the Society at Rochester, N. Y., May 13 to 18, has so broad an appeal that it is difficult to pick from it any one feature without neglecting others which many may consider of more importance. Those who attended the meeting know from their own experience what discussions proved most stimulating, and those who have studied the program and read the papers which had for them an especial appeal will look forward to the final printing, with discussion, in the Society's publications. To these and to others who did not attend the meeting, this review is addressed.

Machining With Tungsten Carbide Tools

Tungsten carbide cutting tools have provided a new problem for builders and operators of machine tools. This remarkable material which has such superior wearing qualities as compared to high-speed steel, especially in cutting substances which quickly dull ordinary tools, has been described and discussed extensively during the past year and has excited much curiosity and speculation. Aside from the description of its properties and a few statements of some of the spectacular feats performed by it, little information concerning its practicability in the every-day life of production service has been published. For this reason it is quite natural to call attention first to the session of the Machine Shop Practice Division at which this new cutting material was discussed from the viewpoint of the user.

As a result of a meeting last December of the Special Research Committee on the Cutting of Metals, the Sub-Committee on Machinability undertook an investigation of the present status of tungsten carbide as a cutting material. The report of this committee was prepared and read at Rochester by Frank C. Spencer, assistant superintendent, machinery procurement, Western Electric Company, Kearny, N. J. The report was available in mimeograph form at the time of the meeting and will be published later by the Society. It divides naturally into three parts: a list of various brands being manufactured, an investigation of the extent to which industry has adopted tungsten carbide for production purposes and the results which are being obtained by its use, and an inquiry into the probable effect which the material will have on the future development of machine tools.

Another paper, read at this same session and dealing with the same subject, dealt with experiences which one manufacturer has had in the use of this new cutting material. The authors were Henry J. Long and W. Paul Eddy, Jr. While not received in time for preprinting, the paper, as also the report by Mr. Spencer, has been generously treated by the technical press and will be published as soon as possible by the Society. Messrs. Long and Eddy first discuss the design and fabrication of tools with tungsten-carbide cutting edges. Experiences in the use of such tools in cutting malleable and gray cast iron and alloy steel are given and the performances are compared with those obtained on the same pieces by the use of high-speed-steel tools. The authors also devote some space to unsuccessful applications of the new cutting material. In their conclusions they state that it is evident from their experience that tungsten carbide alloys are to have an important place in the metal-cutting industries, but only after careful investigation. Advances will be slow in view of the high cost of the material, they reason. The next move is pointed out as being up to the machine-tool builder, although they believe the future of these alloys as factors in efficient manufacturing to be in the hands of users of machine tools.

"We wonder," they conclude, "also as to the fate of the present tungsten carbide alloys when they shall be required to work on machines which have begun to grow a bit old in service. Will it be possible to construct machines that will remain sufficiently rigid and vibrationless, throughout lives of reasonable length, to permit these tool materials to operate without chipping? Or will it become necessary to develop new alloys, possibly with tungsten carbide as the base, but containing larger amounts of cobalt or other metal, which will be stronger and tougher than the present alloys, even at some sacrifice of hardness? These are questions which must soon be answered."

The Teaching of Advanced Mechanics

Engineering can progress up to a certain point on a purely empiric basis, but as schemes grow larger and more ambitious and as invisible forces rather than static masses become involved, preplanning with the aid of applied science is the only practical course to pursue. The Society keeps fresh its contacts with science through its Applied Mechanics Division. A feature of this Division's program at the Rochester Meeting was the session devoted to the teaching of advanced mechanics. J. Ormondroyd, of the Westinghouse Company, and S. Timoshenko, professor of mechanical engineering at the University of Michigan, who presented the papers, have a common background in the Westinghouse Company and its experiences in finding men equipped to handle the perplexing analytical problems which face designers of modern power machinery. They described the work undertaken by the design section organized at the Westinghouse Company by George M. Eaton, and other ways by which young engineers may obtain a more advanced knowledge of applied mathematics and advanced mechanics. Their plea that the engineering schools should provide opportunities for this type of training was met with a varied response by educators and engineers who participated in the discussion. While many ways were pointed out by which this type of education may be got by the young engineer, the conviction still remains that something is wrong with educational systems which leave students with hazy comceptions of fundamental scientific principles and a lack of ability to apply the scientific method to the solution of problems in engineering design. The papers and a brief account of the discussion which they drew forth are to be published in a later issue of Mechanical Engineering.

Training for Those in the Industries

At another session at Rochester, other phases of engineering education were discussed. College education is well organized, even if it may be subject to criticism and further development, but outside of this field there is a great need for a type of education commonly available in Europe, but without parallel in this country except in isolated instances. This is a further training for men already in the industries who are not bookminded but who wish a definite training for future advancement. W. E. Wickenden, president-elect of the Case School of Applied Science and director of investigation, S.P.E.E., discussed this phase of education in a paper entitled "The Technical Institute—European Examples and Their Significance for American Education." With two other papers on training for the industries and a discussion which was so lively that it almost succeeded in making the participants miss the very excellent party at Miss Kate Gleason's home, the session was noteworthy and stimulating.

Research Activities

Just as the sessions on applied mechanics and education showed the contacts with science and organized knowledge, so also did other sessions show the reaching out of engineering toward other fields for the elements and opportunities for its progress. At the sessions on heat transmission, boiler-furnace refractories, and petroleum, for instance, striking evidence was had of the fundamental contributions of research. The papers by Heilman and McMillan on heat transmission proved in a very practical way how research and scientific knowledge can be made available for ready use by designers. The reports on boiler-furnace refractories represent an important research activity of the Society. H. Diederichs and H. O. Pomeroy reported an extensive study of a perplexing problem in industrial research, undertaken by a manufacturer for the purpose of obtaining information on surges in the discharges of pumps.

Management Problems

As evidence of an ever-broadening tendency which engineering has to include new fields, the papers delivered at the management session are interesting examples. Here engineering joins hands with industry in production control and sales synchronization. Prof. D. B. Porter, an enthusiastic Gantt cartographer, offered another example of the very definite value of the Gantt progress chart in controlling the manufacturer of parts on order and for stock. Howard M. Hubbard carried engineering methods still further to effect the synchronization of sales and production by means of budgetary control.

Both of these papers had previously been presented before the Metropolitan Section, and as an item of interest in the technique of engineering meetings, attention should be drawn to the excellent results obtained by this practice. Both authors learned from the initial presentation of their papers certain improvements in method which were put into practice at Rochester, and their messages were delivered with greater effect because of this previous experience.

That there were many other equally excellent sessions and papers at Rochester, those who attended and heard them will attest. There are also those who are grateful for the opportunity afforded to inspect Rochester's famous industries: and still others who will remember the technical-committee meetings which lasted throughout the meeting and into the following day. The Council was well represented and found a difficult agendum before it. The hard work of many weeks by local committees was rewarded by the enjoyable and profitable days spent at Rochester and the results which were accomplished there.

Aeronautics at St. Louis

Third National Meeting of A.S.M.E. Aeronautic Division, May 27-30, 1929

THE intense interest in aviation is one of the phenomena of today which more conservative folk find it difficult to explain. Spectacular features abound in aeronautical development, but beneath these is a broad foundation of patiently applied knowledge to a new problem firmly established by science and engineering. Remarkable as was Colonel Lindbergh's flight to Paris, it must not be forgotten that his patient preparation called to aid whatever could be of service to him and reduced to a minimum the factors which were determined by chance. Intelligent planning, which was the keynote of the success of this venture, is typical of engineering methods.

In the program of events of the Third National Aeronautic Meeting, held at St. Louis, Mo., May 27 to 30, there was a combination of the spectacular and the commonplace. Opportunities were given to ride in airplanes, to see the fliers in the air, to witness racing and stunting, to participate in model contests, and to view exhibits of engines, planes, and accessories. All this was intensely interesting and served a useful purpose, both to the idly curious and to the intelligent observer whose professional interests gave greater meaning to these opportunities, but most satisfying of all from the standpoint of engineers was the program of technical papers. This substantial portion of the general activities presents a truly remarkable group of writers and a long list of topics so diversified in interest that all features of the new industry and science will be found represented. Those who are interested in this feature may consult the program, and through the Society's publications may read the papers which are most strongly appealing. In such a short review as this, no attempt can be made to summarize these technical contributions nor to evaluate them. They are entirely capable of standing on their own merits as additions to our knowledge in this field.

Brilliant as have been the previous national gatherings of the Aeronautic Division, the St. Louis meeting is a splendid achievement consistent with the spirit which has pervaded the Division since it first came into being. In the dark days of aeronautical development in the United States caused by the depression following the war, some of the members of the Society who had been active in the early history of aeronautics appealed to the Council not to neglect the infant industry. Military aviation had made spectacular advances, but evidences of it were mostly in Europe, and a transition to peace-time conditions meant the development of an industry in a country glutted with surplus and obsolete wartime planes and engines, and filled with skeptics—where the airplane was considered a military weapon, a dangerous toy, and an expensive luxury.

By sponsoring the cause of aeronautics the Society gave the weight of its reputation to the balancing of these prejudiced views and unfavorable economic conditions with special engineering knowledge and practical engineering development. Through the publicity of its meetings and publications, and through the activities of its individual members who have been connected with the industry, the Society has performed a unique service which it might easily have neglected. Now that conditions are more favorable and the country is becoming air-minded, there is cause for much satisfaction.

An infant branch of industry and engineering like aeronautics has new fields to develop. It draws its personnel and its experience from older and better-known fields. But it also makes its contributions, not only to the solution of its own problem, but to the general knowledge and advance in other lines. The contacts it forms increase the scope of older activities. It throws into the general machinery of life some complicating monkey-wrenches, but these are more generally employed in the useful service of rebuilding the machine than in wrecking it. The stimulus to other activities which new developments excite by the competition they offer is a spur to progress and an antidote for complacency.

It is in such thoughts as these that the meaning of the technical features of the St. Louis program is to be found.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Memoirs and Addresses of Dr. J. A. L. Waddell

MEMOIRS AND ADDRESSES OF TWO DECADES. By Dr. J. A. L. Waddell. Edited by Frank W. Skinner. Mack Printing Co., Easton, Pa., 1928. Cloth, 6 × 9 in., 1174 pp., illus., $5, postpaid.

REVIEWED BY HORATIO P. VAN CLEVE[1]

IN ONE of the early chapters of this new book, "Memoirs and Addresses of Two Decades," a chapter of somewhat fanciful character, delivered as an address in 1918, Dr. Waddell predicts that an engineer will be elected president of the United States in 1932. That this fancy has become fact four years ahead of his predicted date, does not alter the truth of the idea he intended to convey, namely, that an engineer would soon be recognized as worthy of the most important office this country has to give.

If any engineer who reads this magazine has misgivings as to the importance of his calling, "regarding it," in this author's words, "merely as a means of earning a living, and not as the mainspring of the world's activity and progress," he can find plenty of encouragement and, what is more, inspiration in these addresses.

The book contains 68 chapters and is copiously edited by Frank W. Skinner, consulting engineer. Dr. Waddell's engineering career has extended over more than half a century and embraces the years of the greatest development in all lines of engineering. He has seen steel and concrete replace wood and iron as the basic materials of engineering structures, and has had a vital part in the progress made in the uses of the new materials. His comprehensive investigations into the use of alloy steels in bridge work are published in this volume, investigations which have led to the use of these steels in many important bridges. He is the father of the commonly accepted principle that joints in important structures should fully develop the strength of the connected members.

The book is written in clear, forceful English, and makes pleasing and interesting reading, gripping and holding the attention throughout; it will prove a worthy addition to any engineering library.

The addresses and papers are divided into eleven groups, as follows: 1, The Engineering Profession; 2, Ethics of Engineering; 3, Technical Education; 4, Engineering Literature; 5, Alloy Steels for Bridge Construction; 6, Economics; 7, Bridge Construction in General; 8, Contracts; 9, Railroad Subjects; 10, Matters Chinese, and 11, Miscellaneous Topics.

As these titles indicate, the book, although the work of a bridge specialist has much in it of general interest to the engineer, no matter what his particular specialty may be. Dr. Waddell has stood four-square for breadth in engineering education, and no proof of his position in this respect could be found better than this collection of his addresses.

Mr. Skinner, himself an author and engineer of note, and for many years an able editor of engineering periodicals, has done an excellent piece of work on this book.

America has produced many great engineers, men who have left behind them enduring work of monumental character, but few of them have been authors, and none have left such complete records of their work as Dr. Waddell will leave behind him.

[1] Truscon Steel Co., Youngstown, Ohio. Mem. A.S.M.E.

Chemical Testing of Engineering Materials

ENGINEERING CHEMISTRY. By Thomas B. Stillman; revised and enlarged by Albert L. Stillman. Sixth edition. Chemical Publishing Company, Easton, Pa., 1928. Cloth, 6 × 9 in., 1093 pp., 235 illus., $12.50.

REVIEWED BY JULIAN A. SOHON[2]

IN THE preface the author states that "this volume is a manual of testing of engineering materials to determine their use or lack of availability in industry. Chemical analyses must be supplemented by physical tests and microscopic examination. All these methods have been described, especially when fully standardized, and their relations to each other outlined. For assistance in interpretation, specifications in full are added and supplemented with suggested forms of report, together with some discussion of the place of such materials in industry."

The book takes up the testing and analysis of ores, stone, clay, brick, and cement; the testing and examination of metals and alloys; solid fuels; gas analysis; oils or liquid hydrocarbons; analysis and testing of soap, cleaning compounds and grease; paint and varnish analysis and testing; water analysis; physical and chemical examination of paper.

In short, it is a reference book to standard methods of chemical and physical testing. Each chapter starts with a short explanation or definition of the material under discussion, which is followed by an outline of the tests that are made.

Then standard methods of sampling are given, quoting from specifications whenever possible. The various physical properties and the tests for them are described, and the purpose of the tests is discussed. Where special apparatus or machines are used, these are described. Chemical tests are also described in detail, and the advantages and disadvantages of the different methods are given.

The book is an excellent reference work for students and chemists and those engaged in chemical industries. It should also prove useful to the engineer as a source of information for tests

[2] Chief Bibliographer, Engineering Societies Library, New York, N. Y.

that are made, and should be made, on the most common materials in order to insure their quality and suitability for various uses. It also shows how these tests are interpreted and applied in specifications.

Much of the information it contains is widely scattered in periodical literature and publications that are frequently inaccessible, and the fact that it has collected this information in one volume will make the book valuable to those who should know how to test the materials with which they work.

Books Received in the Library

ARTIFICIAL SILK. By O. Faust. Isaac Pitman & Sons, New York, 1929. Cloth, 6 × 9 in., 184 pp., illus., diagrams, tables, $3.

The first half of this work is devoted to the scientific study of the chemical and physical characteristics of spinning solution and fiber, and the chemistry and physics of the spinning process. The second section discusses technical matters, such as raw materials, spinning processes and apparatus, after-treatment processes and the manufacture of the various silks.

BLAST FURNACE PRACTICE, vol. 1. By Fred Clements. Ernest Benn, Ltd., London, 1929. Cloth, 8 × 10 in., 538 pp., illus., plates, diagrams, tables, 3 charts in pocket, 63s.

This is by far the most ambitious treatise on the iron industry that has appeared in English. The author, the General Manager of the Park Gate Iron and Steel Company, has undertaken to digest the great mass of print that exists and to weave it into a comprehensive account in combination with private information from iron-masters all over the world.

The present volume is concerned chiefly with general principles of furnace operation and with the production and handling of ore, coke, and other raw materials. Nearly 400 illustrations are given, as well as many charts and tables. Two more volumes are planned.

DYNAMICS. By A. S. Ramsey. University Press, Cambridge, Eng., 1929. Macmillan Co., New York. Cloth, 6 × 9 in., 259 pp., diagrams, tables, 10s. 6d.

Intended primarily for those preparing for a first honors examination in an English university and based upon lectures at Cambridge. Some knowledge of the calculus and elementary dynamics is assumed. Many worked and unworked examples are included.

HISTORY OF MANUFACTURES IN THE UNITED STATES, vol. 1; 1607–1860. By Victor S. Clark. McGraw-Hill Book Co., New York, 1929. Published for the Carnegie Institution of Washington. Cloth, 7 × 10 in., 607 pp., maps, 10 × 7 in., $15.

This is a revision of the volume published by the Carnegie Institute of Washington in 1916, which has been out of print for several years. It is now republished and will be extended later in the year by two volumes bringing the story down to the present time.

Dr. Clark has provided a basic work for students of manufacturing. It is strictly an economic history, not an account of technology and mechanics, but students of the latter will nevertheless find it valuable and be helped further by the bibliographic footnotes. The book is a pioneer work, based on original material, which interprets the development, organization, and economic interactions of our manufacturing industry from its beginnings to the time when the nation changed from an agricultural to an industrial state.

HISTORY OF MATHEMATICAL NOTATIONS, vol. 2; Notations mainly in higher mathematics. By Florian Cajori. Open Court Publishing Co., Chicago, 1929. Cloth, 6 × 9 in., 367 pp., $6.

The concluding volume of Dr. Cajori's history discusses the symbols of advanced arithmetic, algebra, and geometry, and of modern analysis. The two volumes contain almost all the symbols used down to the beginning of the nineteenth century and a representative selection of those occurring in recent writings. The amount of research that the work represents is extraordinary, and the history will be of great usefulness to mathematicians.

JAHRBUCH DER HAFENBAUTECHNISCHEN GESELLSCHAFT, vol. 10, 1927. Verlag der Hafenbautechnischen Gesellschaft, Hamburg, 1928. For sale by V.D.I. Verlag, Berlin. Cloth, 9 × 12 in., 222 pp., illus., diagrams, maps, cloth, 30 r.m.

Engineers interested in learning how German and Dutch harbors are equipped will find much information in this yearbook, which contains good descriptions of several important docks on the Rhine and in Holland. Particular attention is paid to machinery for handling coal and other bulk freight.

There are also extensive articles on the construction of the Rotterdam quay walls and the lighting and buoyage of the Elbe. A short account of the oil loading plants at the Chilean oil field is given. All the articles are profusely illustrated with drawings and photographs.

DIE KALKULATION IM MASCHINENBAU. By Hugo Bethmann. Second edition. Ber. u Lpz., Walter de Gruyter & Co., Berlin, 1929. Cloth, 4 × 6 in., 127 pp., illus., diagrams, forms, 1.50 r.m.

An elementary textbook on costing in machine shops. Time studies of various operations are explained, and consideration is given to the determination of manufacturing costs and selling prices.

MANUFACTURE OF PULP AND PAPER, vol. 5. Second edition. By Joint Executive Committee on Vocational Education representing the . . Industry of the U. S. and Canada. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., various paging, illus., diagrams, tables, $6.

This volume is the concluding part of a work prepared under the direction of the Canadian Pulp and Paper Association and the Pulp and Paper Industry, which aims to provide a textbook covering the fundamentals of mathematics and science and the principles and practice of pulp and paper manufacture. The course of study is arranged definitely for home study.

About one-half of this volume is devoted to paper-making machines. The other topics are hand-made papers, tub sizing, paper finishing and testing, coated papers and paper-making details. The new edition has been thoroughly revised, several sections have been rewritten, and some new topics have been added.

S.A.E. HANDBOOK, 1929. Society of Automotive Engineers, New York, 1929. Fabrikoid, 5 × 8 in., 680 pp., diagrams, tables, $5.

The 1929 edition follows the plan of previous years, but has been brought up to date by the inclusion of the changes adopted by the Society during 1928. Over six hundred specifications and recommended practices are included, covering the materials, machine parts and elements of automobiles, motorboats and aircraft.

STATISTICAL MECHANICS . . . . based on an Essay awarded the Adams Prize in the University of Cambridge, 1923–24. By R. H. Fowler. University Press, Cambridge, 1929. Macmillan Co., New York. Cloth, 8 × 11 in., 570 pp., tables, $10.50.

At the time (1924) when this work was begun, there was no recent exposition of the equilibrium theory of statistical mechanics, and the book is still the only one in English. The work aims to give a connected account of the theory, by the method developed by the author and Professor Darwin, with an exposition of its applications to physical and chemical problems. The book incorporates the results of the new mechanics, as well as those of classical mechanics.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current issues of Aeronautical Engineering, and in the Iron and Steel, Printing Industries, and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

AERONAUTICAL ENGINEERING PAPERS

PROGRESS IN AERONAUTICS. [Paper No. AER-51-1]

This report, prepared by the Aeronautic Division of the A.S.M.E., reviews developments in the field it covers during the year 1928. The information it contains is presented under the headings: Power plants; airplane design and construction; aerodynamics; air transport and other civil flying; progress in naval and military aviation; and airships. Among the tables included are one giving the air-transport mileage of the world, and another presenting comparative data on the *Los Angeles*, the *Graf Zeppelin*, and the *ZRS-4*.

PROBLEMS OF COMMERCIAL-PLANE PRODUCTION. By Walter H. Beech. [Paper No. AER-51-2]

The author compares conditions in the aircraft industry today with those which obtained in the automobile industry during its infancy; there are no precedents to guide, no sources of supply established, and no types determined. He then discusses six factors which enter the construction of a commercial plane—safety, airworthiness, performance, durability, comfort, and appearance. Considerable attention is paid by the author to the airplane-engine situation, which is unfavorable to airplane manufacturers. This is followed by a discussion of factory machinery and equipment, labor, and a brief description of the straight-line production system of the Travel Air factory. The paper closes with a short discussion of production methods of the future.

HISTORICAL SKETCH OF THE DEVELOPMENT OF AERODYNAMIC THEORY. By W. F. Durand. [Paper No. AER-51-3]

This paper is intended to give, in brief historical outline, a sketch of the development of aerodynamic theory from the time of Newton to the present day. Newton's theory of fluid motion and the resulting formula for the force reaction resulting between an inclined plane and a fluid in relative motion are briefly stated and the insufficiency of the formulas noted. Reference is then made to the various mathematical aids which were developed during the next century, and which made possible the investigation of fluid motion based on the concept of continuous change and the "perfect fluid" of the mathematician. The limitations of this concept, especially with reference to the explanation of force reactions between the body and the fluid, are then noted, together with the introduction of the idea of "circulation" and generally of the physical picture as developed by Lanchester and then in mathematical form by Prandtl and his school. These are then briefly sketched and the results of the introduction of these new ideas indicated.

Reference is then made to the problem of the drag, only in part taken care of by the Lanchester-Prandtl vortex theory, and to von Karman's work leading to his concept of the "Karman vortex street" and thence to the measurement of a further element of the drag; and finally to the third element (depending on skin friction) as at present dependent chiefly on direct physical measurement. In addition to the problem of lift and drag, the problems of stability and control in the air are briefly referred to, followed by mention of the dependence of theory on experimental research and to the vast amount of wind-tunnel investigation which has been made during the past two decades. Brief mention is then made of the two problems introduced by such work—the correction for "wall interference" and the "scale factor" due to the imperfect fulfilment of the conditions for kinematic similitude. This section closes with a mention of some of the problems which characterize the advancing fringe of progress in aerodynamic theory and which in large part still remain for future examination and study.

Then follows a brief section dealing with the screw propeller, with reference to the chief stages of the development of propeller theory as suggested by the names Rankine, Froude, Drzewiecki, Prandtl, and closing with a suggestion of some of the problems which characterize the advancing fringe of this phase of general aerodynamic theory.

SOME NOTES ON AIRPLANE PRODUCTION. By Jerome Lederer. [Paper No. AER-51-4]

This brief paper, in addition to discussing other problems, outlines the procedure of an automobile company that without previous experience in such work, went successfully into the production of airplanes on short notice.

WOOD INDUSTRIES PAPERS

ENGINEERING CHARACTERISTICS OF PLYWOOD. By Thomas D. Perry. [Paper No. WDI-50-13]

After describing the kinds of veneer and glue used in making plywood, the author discusses its strength characteristics, its applications in shipbuilding, automotive and airplane construction, containers, and furniture manufacture. He then describes types of plywood construction and testing methods. The paper includes tables of weights of veneer of various species and thicknesses; of strength of various species of 3-ply panels; and of the tensile strength of plywood and veneer made from some 35 different species of wood.

EFFICIENCY METHODS AND STANDARDS IN GERMAN WOODWORKING INDUSTRIES. By Robert Schluetter. [Paper No. WDI-50-14]

This paper comprises a brief description of work being carried on in Germany under Government auspices for the purpose of attaining higher efficiency in woodworking. It includes a glossary of German technical terms used in woodworking.

AUTOMATIC PRODUCTION OF SMALL WOOD PARTS. By I. B. and G. A. Whinery. [Paper No. WDI-50-15]

The authors point out that more attention has been given to the design of hand-fed and manually controlled general-purpose machinery for woodworking than to the building of automatic machines. Among other reasons it is shown that the set-up time is generally long as compared with the working time because of the rapidity with which wood can be worked.

As examples of automatic woodworking machines the authors describe three: (1) A knob-tapping machine, chosen to show how production may be increased by performing a single operation more rapidly than the best operator could do it by hand; (2) a square-knob blanking machine to illustrate the combination of several distinct operations in one mechanism; (3) a rosette machine as an example of one the primary purpose of which is to achieve quality without sacrificing speed.

The economic principles involved in the use of automatic woodworking machinery are discussed in the remainder of the paper.

OBTAINING THE MAXIMUM FUEL VALUE FROM WOOD WASTE. By E. Winholt. [Paper No. WDI-50-16A]

After consideration of the probable amount of lumber wasted in the average woodworking establishment, the author discusses the best method of arranging a boiler plant for the efficient utilization of wood as fuel, and describes installations to care for special conditions. He also deals with methods of avoiding explosions in furnaces and shavings pipes.

WOOD-BURNING FURNACES. By Burritt A. Parks. [Paper No. WDI-50-16B]

After pointing out the value of wood refuse as fuel for boilers in woodworking plants, the author discusses the nature of wood refuse and the heating value of various species of wood. He then considers

the conditions necessary for the efficient combustion of wood refuse, and sets forth the principal requirements in the case of kiln-dried wood, after which he describes various furnace designs which have been successfully employed. He closes with an appeal for better engineering in the design and operation of woodworking plants.

PRINTING INDUSTRIES PAPERS

THE STANDARDIZATION OF COLORED PRINTING INKS AND ITS ADVANTAGES. By Taylor W. Anstead. [Paper No. PI-50-4]

The author discusses briefly the materials entering into the manufacture of printing ink. Since the pigments used in their manufacture exhibit the widest variations, standardization of colored inks is really the standardization of the pigments involved. Various proposed methods of standardization are considered, and it is hoped that out of their discussion some practical system will result that will do away with the present confusion.

THE SPIRIT OF THE CREATIVE AGE. By Robert W. Disque. [Paper No. PI-50-5]

The author traces the art of printing from its inception to the present, and shows how marvelous has been the contribution of the mechanical engineer to its development.

MODERN BRONZING PROBLEMS AND METHODS. By William C. Glass. [Paper No. PI-50-6]

After showing how highly throughout the ages gold has been regarded for decorative purposes, the author states that public demand is the reason for the present universal use of bronze for decorative purposes in printing. He then successively describes the vacuum bronzer, automatic conveyors for bronzing machines, and modern high-speed vacuum bronzing machines, stating points to be observed in their operation.

THE ART OF PHOTO COMPOSING, OR PHOTO-MECHANICAL IMPOSITION. By William C. Huebner. [Paper No. PI-50-7]

The author shows how in color printing precise register is the prime desideratum. Photo composing, the new art of making printing plates wherein original designs are photographed directly on the press plate from which the finished edition is printed, supplies the means of obtaining the close register required, and the author describes briefly the methods by which it is accomplished.

REPORT OF RESEARCH AND SURVEY COMMITTEE OF THE PRINTING INDUSTRIES DIVISION. By Arthur C. Jewett. [Paper No. PI-50-8]

In this brief report it is suggested that a large council of all technical men interested in the printing industry should be organized to discuss the research field in its various ramifications.

PHOTOGRAPHY AS USED IN COLOR REPRODUCTION IN THE GRAPHIC ARTS. By A. J. Newton. [Paper No. PI-50-9]

Indications are that the demand for color in the graphic arts, produced by means of photography, will continue to increase, and this means that, as the fundamental principles appear to be well established, further improvements will be made in machinery and materials and the skill in using them; and particularly in adjusting practice as closely as possible to theory, so that color reproduction, while maintaining the highest possible quality, will be produced more speedily and more economically.

THE FIELD OF LITHOGRAPHIC PRINTING. By George C. Van Vechten. [Paper No. PI-50-10]

In this paper the author presents a brief survey of the various processes, materials, machinery, and operating methods employed in lithographic printing, with special reference to multi-color work.

IRON AND STEEL PAPERS

SHEET ROLLING. By Leon Cammen. [Paper No. IS-50-9]

In this paper, after distinguishing between strip and sheet, and between hot and cold rolling, the author points out that mills are today rolling to surface specifications which would have been considered impossible five years ago, and that barring certain contingencies, stricter specifications may prevail in the near future. In the course of his treatment of the subject he discusses the continuous process of sheet rolling, temperature and labor, roll life, engineering economics of the sheet-rolling business, rolling with heating between passes, sheet rolling in Germany, sheet and roughing mills of the future, the price problem, etc. In the author's opinion the economic side of the industry will have to be reorganized, reducing the number of plants and concentrating output in larger and better-equipped units capable of meeting the strenuous specifications of today in an economical manner by those knowing enough about their costs to demand a fair price for their products.

THE MANUFACTURE OF NICKEL-STEEL PLATE. By Charles McKnight and W. G. Humpton. [Paper No. IS-50-10]

This paper deals with the manufacture, rolling, and inspection of steels containing between 2 and 3 per cent of nickel and which are used in boiler construction, and particularly with the manufacture of fairly large plates of from $\frac{1}{4}$ to $1\frac{1}{2}$ in. in thickness. The physical properties of the metal are first discussed, following which details are given of its manufacture, beginning with the ingot phase and proceeding then step by step through stripping and reheating, rolling, flattening, inspecting and shearing, and finally, testing.

ROLLING-MILL LUBRICATION. By L. P. Tyler. [Paper No. IS-50-11]

The author confines his discussion to those modern installations where lubrication is effected by means of a system which automatically circulates a single lubricant. He first considers the mill members best adapted to such lubrication, following which he outlines the conditions to be satisfied for correct lubrication. The requirements to be met by the lubricant are then enumerated, and instructions are given for its application and handling. Finally the advantages of economy and compactness of design it permits are shown.

NOTE: Those who have not registered in the A.S.M.E. Aeronautics, Iron and Steel, Printing Industries, and Wood Industries Divisions, whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

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THE ENGINEERING INDEX

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Mechanical Engineering Section

THE ENGINEERING INDEX furnishes a Weekly Card Index Service of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Items of particular interest to mechanical engineers are selected for presentation each month in this Mechanical Engineering Section. In operating The Engineering Index, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession.

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ACCIDENT PREVENTION

Iron and Steel Plants. Safety in the Steel Mills, F. H. Rowe. Rolling Mill Jl., vol. 3, no. 3, Mar. 1929, pp. 135–136. Well guarded and improved types of equipment such as cranes, motors, rolling-mill machinery, etc., together with well-established safety work, result in good safety records; responsibility of management for application of safety principles.

AIR COMPRESSORS

Flywheels. Calculation of Flywheels for Air Compressors, H. R. Goss and H. V. Putman. Am. Soc. Mech. Engrs.—Advance Paper, no. 11, for meeting, May 13 to 16, 1929, 14 pp., 26 figs. Short history of application of low-speed synchronous motors direct connected to ammonia compressors and application of synchronous motors to air compressors; special problems encountered due to unbalanced weights of reciprocating parts and to part-load operation of air compressors; formulas for calculating theoretical indicated horsepower for single- or for two-stage multi-cylinder compressors; methods of calculation of theoretical torque curves for compressors.

AIRPLANE ENGINES

Cowling. N.A.C.A. Cowling Experiments Interest S.A.E. at Detroit, C. W. Lewis. Automotive Industries, vol. 60, no. 16, Apr. 20, 1929, pp. 627–628. Origin and application of airplane engine cowling developed by National Advisory Committee for Aeronautics, are described; wind tunnel testing of ten types; disappointing results at first obtained with cowling on three-engined planes; necessity for research on each new type of plane and engine to which cowling is applied; adoption of T-head cylinders with exhaust valve in front suggested for increasing speed further. Abstract of paper presented before Soc. Automotive Engrs.

Testing. Commercial Aircraft Engines, H. C. Dickinson. Aero Digest, vol. 14, no. 4, Apr. 1929, pp. 102, 274, 276, 278 and 280, 1 fig. Development and testing of airplane engines from point of view of safety and regulation; description of tests of commercial aircraft engines made by Bureau of Standards for Aeronautics Division of Department of Commerce; type test requirements of Department contained in Air Commerce Regulations. Paper presented before Int. Civil Aeronautics Conference.

Performance-Testing of Aero Engines, G. B. Hynes. Aeroplane (Lond.), vol. 36, no. 12, Mar. 20, 1929, p. 458, including discussion. Engine performance testing is discussed; difficulty in obtaining satisfactory flying results which could be compared with figures obtained on test bench; apparatus used for various investigations; type testing; compilation in testing supercharged engines. Abstract of paper presented before Roy. Aeronautical Soc.

AIRPLANE PROPELLERS

Testing. Full Scale Tests on a Thin Metal Propeller at Various Tip Speeds, F. E. Weick. Nat. Advisory Comm. for Aeronautics—Report, no. 302, 1929, 14 pp., 11 figs. Investigation made to determine effect of tip speed on characteristics of thin-bladed metal propeller; propeller was mounted on VE-7 airplane with 180-hp. E-2 engine and tested in 20-ft. propeller research tunnel; effect of tip speed on propulsive efficiency was negligible within range of tests, which was from 600 to 1000 ft. per sec. (about 0.5 to 0.9 velocity of sound in air).

AIRPLANES

Autogiros. Characteristics of an Autogyro, H. Glauert and C. N. H. Lock. Aviation Eng., vol. 2, no. 5, May 1929, pp. 9–10, 2 figs. Summary of experimental and theoretical investigations of characteristics of autogiro; development of theory; full-scale experiments; wind-tunnel experiments at National Physical Laboratory and Royal Aircraft Establishments; comparison of airplane and gyroplane.

Burnelli. An Original Design. Flight (Lond.), vol. 21, no. 13, Mar. 28, 1929, pp. 254–255, 7 figs. See also L'Aéronautique, vol. 11, no. 118, Mar. 1929, pp. 93, 94, 6 figs. Construction of unusual Burnelli plane with wide airfoil-section fuselage, acting as surplus wing area, is described; fuselage consists of extruded dural, heat-treated, drawn to various sections, angles, tees and channels built up into truss framework covered with corrugated dural; details of cabin which accommodates 20 passengers; two 500-hp. Curtiss Conqueror engines.

Control, Automatic. Automatic Control of Airplanes, Loss of Speed, and the Constantin Wind Vane (La stabilisation automatique des avions la perte de vitesse et la girouette Constantin), L. Constantin. Société d' Encouragement l'Industrie National—Bul. (Paris), vol. 12, no. 2, Feb. 1929, pp. 121–137, 4 figs. Description of Constantin wind vane and its application to airplane control surfaces for automatically controlling stability of airplane; vane can be set so as automatically to control plane for flight at given angle of attack; operation of vane with loss of speed is explained.

Frames, Stresses in. Development of Metal Construction, H. J. Pollard. Flight (Lond.), vol. 21, no. 17, Apr. 25, 1929 (Aircraft Engineer Sec.), pp. 25–28, 6 figs. Calculation of moments of inertia of beams made up of corrugated strip of small thickness; moment of inertia of flange about central axis of spar; moment of inertia of web about same axis obtained in similar manner, thus giving total moment of inertia of section; fiber stresses in spar when given loads come on to it can be determined; stress at which elastic instability is likely to set in must be estimated for these flanges and webs.

Experimental Determination of the Stresses in the Framework of Airplanes (Determination experimentale des tensions dans les charpentes d'avions), W. Margoulis. Aeronautique (Paris), vol. 11, no. 118, Mar. 1929, pp. 81–83, 3 figs. Description of apparatus developed for testing airplane frames, similar to photoelasticity method developed by Mesnager, and based upon measure of strain optically by photoelasticity method; tests on Gourdore and Leseurre pursuit plane described; principles of apparatus employed for making photoelastic measurements are explained.

Fuselages, Strength of. On the Strength of Box-Type Fuselages, J. Mathar. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 511, May 1929, 11 pp., 15 figs. on supp. plates. Investigation of fuselage with sides of thin smooth sheet metal, stiffened by longitudinal members riveted to flanged channel-section bulkheads or transverse frames and to semi-circular corrugated corner stiffenings; static investigations for bending about beam and vertical axis and for torque; vibrational phenomena investigation covers two bending vibrations and torsional vibrations in conjunction with static investigations. From 1928 yearbook of Wissenschaftliche Gesellschaft fuer Luftfahrt.

Helicopters. See HELICOGYRES.

High-Altitude. The High Altitude Airplane, B. V. Korvin-Kroukovsky. Aviation, vol. 26, no. 16, Apr. 20, 1929 (Aeronautical Eng. Sec.), pp. 54–61, 5 figs. Design of airplane to navigate in stratosphere; possibility of utilizing dense air at lower altitude for take-off and landing, and reduced density of higher altitudes for reduction of air resistance and for increase in speed with means available at present; increasing speed 50 per cent at present power loading; arrangement of power plant and technical possibility of climbing to high altitude; mechanically driven supercharger useless; Rateau turbo-supercharger.

Lift Distribution. Relative Lift Distribu-

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

tion in Any Biplane, L. V. Kerber. Aviation, vol. 26, no. 16, Apr. 20, 1929 (Aeronautical Eng. Sec.), pp. 62–67, 10 figs. With experimental data on special biplane cellules as basis, empirical-theoretical method given permits general solution for lift distribution in any biplane; determination of relative loading for stress analysis work is rationalized; effect of actual lift distribution on induced drag can be found from these data with charts of previous report.

Waxing. Waxing Airplanes, J. V. Steinle. Aero Digest, vol. 14, no. 4, Apr. 1929, pp. 118 and 120, 2 figs. Experimental data on skin friction of waxed surfaces and discussion of practical advantages; skin-friction tests on surfaces formed by coating panels with normal airplane finishing materials, and on same surfaces after applying coating of wax over original surface, aerodynamic and other advantages.

Weight Reduction. Weight of Aircraft, T. M. Barlow. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 220, Apr. 1929, pp. 239–258 and (discussion) 259–268, 14 figs. Various characteristics and influences affecting weight of aircraft with review of possible development with increased size; correct balancing of weight and resistance for maximum efficiency; safety factors; airplane materials; weight saving on fuel and oil tanks, pipe lines and wheels; weight per horsepower; effect of size on engine weight; range and weight.

Wing Design. Design of Thick Airplane Wings (Note sur le calcul des ailes épaisses), L. Kirste. Aéronautique (Paris), vol. 11, no. 118, Mar. 1929, p. 85, 2 figs. Method consists of breaking up stress in spar into bending and torsion; in order that beam may be flexible without torsion, strains in two spars must be identical and bending moments in two spars proportional to their moments of inertia; hypothesis assumed that there is no elasticity in torsion; method developed for large monoplane wing with rigid covering.

AIRPORTS

Class A Types. The Class A Airport, C. C. Hay. Colo. Engr., vol. 25, no. 3, Mar. 1929, pp. 102 and 146, 2 figs. Five requirements of A1A airport which must be met in order to conform to U. S. Department of Commerce standards; size and location of airport; runway surfaces; markings and lighting requirements; hangars and machine shops.

AIRSHIPS

Graf Zeppelin. Airship Graf Zeppelin Viewed from Standpoint of Its Designer (Das Luftschiff Graf Zeppelin vom Standpunkt des Erbauers aus betrachtet), E. A. Lehmann. Glasers Annalen (Berlin), vol. 104, no. 5, Mar. 1, 1929, pp. 71–74. Motives for construction; selection of type; external influences in design; size and capacity; outside hull; control and safety devices; central corridors; fuel and motive power; efficiency; safety and range of operation.

Present and Future State of Airships (l'Etat actuel et l'Avenir du Dirigeable), C. Martinot-Lagarde. Technique Moderne (Paris), vol. 21, no. 4, Feb. 15, 1929, pp. 97–103, 17 figs. Problems of airship design as solved by France and other countries; evolution of rigid airships; design of Graf Zeppelin; transatlantic flight; resistance to bad weather; realization of constant quantity in ascending force by feeding engines with gas of density of air; regular operation of 500-hp. engines during 100 hr. without stopping; safety in navigation methods; advantages of airships to France.

Hull Stresses. The Application of the Principle of Least Work to the Primary Stress Calculations of Space Frameworks, C. P. Burgess. Am. Soc. Mech. Engrs.—Advance paper for mtg. May 27–30, 1929, 8 pp., 3 figs. Structure similar to framework of rigid airship is analyzed by three approximate methods commonly applied to such structures, and also by mathematically exact method of least work; it is shown that approximate methods may be very considerably in error; short-cut method of least work, giving very satisfactory results, is described and applied to structure.

Mooring Masts. Mechanism of Mooring Masts for Airships at Montreal, Canada [Le mechanisme de la tour d'amarrage pour dirigeables de Montreal (Canada)]. Génie Civil (Paris), vol. 94, no. 15, Apr. 13, 1929, pp. 360–362, 4 figs. Details of mooring-mast mechanism which is controlled by compressed air; mechanism is situated in turret of same diameter as that at Cardington but not as high; telescopic arm is suspended from universal joint at vertex of turret, which can be turned around its point of suspension; it all rests inside of revolving cone with axis vertical to 30 deg. opening.

ALLOY STEELS

Recent Developments in. Recent Developments in Alloy Steels, R. Hadfield, W. B. Pickering and S. A. Main. Iron and Steel of Canada (Gardenvale, Que.), vol. 12, no. 4, Apr. 1929, pp. 105–108, 10 figs. Noteworthy technical advances in alloy steels, especially in development of heat and corrosion-resisting steels, and successful industrial applications are outlined; high-percentage nickel-chromium steels; microstructure of Era heat-resisting steel and strength at high temperatures; testing apparatus for finding limiting creep stress of Era steel.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Copper. See COPPER ALLOYS.

Nickel. See NICKEL ALLOYS.

ALUMINUM

Aluminum-Coated Sheets vs. Tinplate. Tinplate vs. Aluminum-Coated Sheets, C. L. Mantell. Iron and Coal Trades Rev. (Lond.), vol. 118, no. 3180, Feb. 8, 1929, p. 212. Employment of aluminum plate as substitute for tinplate investigated in Germany; influence of aluminum of 99 to 99.5 per cent purity on preserved food; Germans planning to erect plants; aluminum-coated sheets light; technology of coating process; tin and aluminum coatings compared; question of their achieving popularity.

ALUMINUM ALLOYS

Aldrey. Aldrey, A. Fuchs. Siemens-Zeit. (Berlin), vol. 9, no. 3, Mar. 1929, pp. 153–157, 4 figs. Mechanical and electrical characteristics of new aluminum alloy as described in Zeit. fuer Metallkunde, no. 19, 1927, p. 460; comparison of copper and aldrey from engineering and economical standpoints; lines executed.

Duralumin. See DURALUMIN.

AUTOMOBILE ENGINES

Balancing. Balancing of Automobile and Airplane Engines (Ueber das Auswuchten von Automobil und Flugzeugmotoren), D. Hofmann. Motorwagen (Berlin), vol. 32, no. 10, Apr. 10, 1929, pp. 212–216, 11 figs. Notes on balancing technique; dynamic balancing machines of different types and their manipulation are described.

Cylinder Blocks, Milling. Milling Angle Pads on Cylinder Blocks As One Manufacturer Does It. Automotive Industries, vol. 60, no. 15, Apr. 13, 1929, pp. 588–589, 3 figs. Method of milling cylinder-block angle pads discussed with details of fixture used; conveyor system brings blocks directly to Cincinnati miller, leaving to operator only task of clamping work in position and controlling action of cutter.

Diesel. See DIESEL ENGINES, Automotive.

Valve Manufacture. Valve Manufacture. Automobile Engr. (Lond.), vol. 19, no. 253, Apr. 1929, p. 134, 2 figs. Details of new method of valve manufacture devised by B.S.A. Tools, Birmingham, which eliminates heavy forming cuts; method enables turning operations to be made semi-automatic and eliminates difficulty of producing radius; use of modified form of B.S.A. form-turning and facing lathe, in which circular-feed tools are arranged for generating required radius, and B.S.A. centerless grinders for rough and finish grinding stem.

Vibration. Controlling Torsional Vibration of Crankshaft Assemblies by Dampers and Modifiers, P. M. Heldt. Automotive Industries, vol. 60, no. 18, May 4, 1929, pp. 684–687 and 701, 4 figs. Factors influencing torsional vibrations of crankshafts are discussed; modification is possible by changing distribution of weight along crankshaft, but increasing engine speeds requires addition of dampers; description of Chrysler full-range vibration damper developed by T. J. Litle, Marmon Automobile Co.; harmonic balancer used on number of General Motors cars.

AUTOMOBILES

Front-Wheel Drive. Front-Wheel Drives, H. Chase. Automobile Engr. (Lond.), vol. 19, no. 253, Apr. 1929, pp. 127–133, 15 figs. Advantages and limitations of front-wheel drive on automobiles and motor trucks are discussed; three classes of front-wheel drive are compared with examples; drive on Bollstrom and Coleman trucks and on French Bucciali car; Ruckstell axle used on Miller and Marmon racing cars; Walter truck; French Tracta and German Kamm front-wheel designs. Paper presented to Soc. Automotive Engrs.

Shock Absorbers. Suspension and Shock Absorbers for Automobiles (La suspension des voitures automobiles les amortisseurs). Pratique des Industries Mécaniques (Paris), vol. 11, no. 11, Feb. 1929, pp. 457–466, 23 figs. Discussion of various shock-absorber designs; means of load deflection; study of internal friction; design of Houdaille, Derihon, and Renault liquid shock absorbers, and Hartford and Dufaux friction shock absorbers explained; Eclipse two-brake absorber; Supless, Merigoux Mulot, and MGR absorbers; Fram-Vermot elastic absorber.

The Principle of Hydraulic Spring Control, B. C. Berry. Bus and Truck Transport in Canada (Toronto), vol. 5, no. 4, Apr. 1929, p. 42, 1 fig. Description of Houdaille hydraulic shock absorber which consists of forged-steel chamber divided into two equal sections by stationary partition in which wing-like piston is oscillated by arm of instrument; chamber is filled with glycerine solution.

Wheels, Light-Metal. Light-Metal Disk Wheels (Leichtmetall Scheibenraeder), W. Hartl. Motorwagen (Berlin), vol. 32, no. 7, Mar. 10, 1929, pp. 149–151, 6 figs. Silumin wheel has been developed which is lighter than sheet-steel disk wheels; saving is effected in cost of production and material by employment of chill casting process; silumin is aluminum alloy containing about 13 per cent silicon.

B

BEARINGS, BALL

Cageless. Ball Bearings Without Cages. Motor Transport (Lond.), vol. 48, no. 1258, Apr. 22, 1929, p. 468, 8 figs. Details of ball bearings designed by a Russian; invention applies only to bearings with two or more rows of balls; cage is replaced by small distancing balls which are held in grooved ring, this being free to revolve inside annular space provided for it inside two halves of outer races; comparative test.

Testing. Comparative Endurance Tests of Various Types of Ball Bearings (Vergleichsversuche ueber die Haltbarkeit verschiedener Kugellager-Konstruktionen), O. Foeppl. Maschinenbau (Berlin), vol. 8, no. 6, Mar. 21, 1929, pp. 189–191, 9 figs. Tests with channel and rocking ball bearings with and without filling aperture in universal joint arrangement in order to avoid additional forces; pure transversal and transversal plus from 10 to 25 per cent longitudinal loads were applied so that after approximately 20,000,000 revolutions breakdown occurred; tabular review of results.

BOILER FEEDWATER

Treatment. Control of Boiler-Water Treatment to Prevent Embrittlement, F. G. Straub. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 13–16, 1929, 2 pp. Author discusses necessity for boiler-room control of treatments used to prevent embrittlement; this control is based upon rapid and sufficiently accurate analysis which may be run readily by boiler attendants; analyses discussed are for total alkalinity sodium sulphate, and sodium phosphate; details of colorimetric method for phosphate; recommends that all boiler-water analyses be checked from time to time by laboratories familiar with water analyses.

Influence of Chemicals in Boiler Feedwater on Steam-Cylinder Lubrication (Die Beeinflussung der Dampfzylinderschmierung durch Chemikalienzusatz zum Kesselspeisewasser), G. Spettmann. Feuerungstechnik (Leipzig), vol. 17, no. 7, Apr. 1, 1929, pp. 75–77. Two examples of harmful effects are cited; only in case of feedwater composed mainly of calcium carbonate with very little magnesia and gypsum and only small quantities of soluble salts, are satisfactory results obtained with lime-soda process.

Points to Consider in Treating Feed Water, H. C. Dinger. Power, vol. 69, no. 16, Apr. 1929, pp. 630–631. Factors in determining arrangements for conditioning feedwater are: removal of air and corrosive and scale-forming ingredients from feedwater involving distilling, pretreatment, filtering, etc.; after-treatment to correct conditions that have not been entirely overcome; proper blowdown procedure to eliminate collection of solids and sludge and to reduce concentrations of impurities in boiler; condition of make-up feed; application of protective surface film; alkalinity of pH control.

BOILER FURNACES

Air-Cooled Refractory Walls. Proprietary Air-Cooled Refractory Walls, C. S. Gladden. Am. Soc. Mech. Engrs.—Advance paper for mtg., May 13–16, 1929, 11 pp., 16 figs. Evolution of boiler furnaces is discussed, also increasing tendencies toward higher ratings of boiler operation and attendant increasing maintenance troubles with refractories: describes some of proprietary air-cooled walls now available for consideration of designing engineers and boiler-plant operators;

operating experiences of certain engineers with air-cooled refractory walls of different types; author's opinion concerning condition suitable for air-cooled refractory-wall installations.

Rotary. The Atkinson Rotary Furnace and Inclined Grate for Steam Boilers, J. S. Atkinson. Engineering (Lond.), vol. 127, no. 3301, Apr. 19, 1929, pp. 501–502, 6 figs. Details of inclined grate. Paper read before Bradford Eng. Soc.

BOILER PLATES

Temperature Effect. Elastic Limit of Steel at Elevated Temperatures (Ueber die Streckgrenze von Stahl bei hoeheren Temperaturen), F. Koerber. Stahl und Eisen (Duesseldorf), vol. 49, no. 9, Feb. 28, 1929, pp. 273–277. Stresses due to higher boiler temperatures are discussed and importance of research is emphasized; relation of temperature to elastic limit of steel; results applied to design of boilers and acceptance specifications for boiler plate.

Testing. The Strength of Boilers, T. Petrie. Engineering (Lond.), vol. 127, no. 3301, Apr. 19, 1929, pp. 493–494. Review of memorandum published by chief engineer of Manchester Steam Users' Assn., devoted mainly to discussion of test made by Association in past years; of these most important were those conducted by L. E. Fletcher on Lancashire boiler built specially for research by T. Beeley in 1874; gives figures as to ratio of test pressures to working pressure sanctioned by experience of Association.

BOILERS

Control. Automatic Control of Boiler Operation (Die selbsttaetige Reglung im Dampfkesselbetrieb), H. Balcke. Brennstoff und Waermewirtschaft (Halle Saale), vol. 11, nos. 5 and 6, Mar. 1929, pp. 81–86 and 100–105, 13 figs. Notes on automatic furnace regulators and their manipulation; description of A.E.G. Askania regulator, and its applications; regulation of air and fuel admission; regulation of pulverized-coal furnaces; excess-air regulation.

Design, Germany. Present Status of Boiler Design in Germany (Der heutige Stand des deutschen Dampfkesselbaus), F. Weber and A. Konejung. Archiv. fuer Waermewirtschaft (Berlin), vol. 10, no. 3, Mar. 1929, pp. 79–88, 15 figs. Influences of rise in pressure, of increase in size of units and efficiency, and of design of boilers and furnaces are discussed; statistical data; safety of boiler; specifications; materials and construction methods; types of boilers; limits of efficiency increase; radiation boilers; special methods of steam generation.

Electric. 1000 Kw. Electric Steam Boiler for Heating Service, J. B. Kitchen. Contract Rec. (Toronto), vol. 43, no. 15, Apr. 10, 1929, p. 382, 1 fig. Toronto Hydroelectric System has installed electric unit to heat building; saves building and fuel storage costs by using off-peak power; annual charges are one-fifth of coal or oil costs; 10 lb. pressure used.

Pulverized-Coal-Fired. Evolution of the Slag-Tap Furnace at the Charles R. Huntley Station of the Buffalo General Electric Co., H. M. Cushing. Am. Soc. Mech. Engrs.—Advance paper for mtg. May 13–16, 1929, no. 7, 8 pp., 14 figs. Account of how engineers in their attempt to design furnace that would burn any coal offered in Buffalo market developed slag-tap furnace for burning powdered coal; reasons why powdered-coal firing was chosen for 60,000-kw. 1926 extension to Charles R. Huntley station; shows how experiments on furnace designed to remove ash in dry form led to development of slag-tap furnaces; advantages are enumerated.

Powdered Fuel Tests on Lancashire Boilers. Engineer (Lond.), vol. 147, no. 3818, Mar. 15, 1929, p. 304, 4 figs. Results of trials made on two boilers fitted with Brand system of pulverized-fuel firing at demonstration station of B. and L. Powdered Fuel, Ltd., at Savill Bros.' Brewery, Stratford; from figures given it may be anticipated that with preheated air 150 deg. fahr. above atmospheric temperature efficiency of Lancashire-type boiler fired on Brand system with pulverized fuel would be about 75 per cent.

Sludge Removal. The Filtrator Boiler Sludge System. Mech. World (Lond.), vol. 85, no. 2207, Apr. 19, 1929, pp. 368–369, 2 figs. Description of continuous blow-down and heat-recovery plant built by Filtrators, Ltd., London; non-chemical system of continuous blow-down of sludge from boilers; suitability of system for application where waters of initially high density are in use; it is claimed that not only is heat saved but consumption of feedwater is correspondingly reduced.

Waste-Heat. The La Mont Waste-Heat Steam Generators. Engineering (Lond.), vol. 127, nos. 3296 and 3298, Mar. 15 and 29, 1929, pp. 341–342 and 392–393, 26 figs. partly on supp. sheet. Mar. 15: In New York City, during last few years, free-surface evaporation is obtained throughout whole length of tubes; as result rate of heat transmission has been increased to over 16 B.t.u. per sq. ft. of heating surface per hr., per degree fahrenheit temperature difference; particulars of installation working in conjunction with water-gas plant at Everett plant of Boston Consolidated Gas Co. Mar. 29: Details of water-gas plant supplying waste gases to steam generators.

Waste-Heat Boilers at Timken Plant. Power, vol. 69, no. 18, Apr. 30, 1929, p. 711, 1 fig. Timken Steel and Tube Co. has installed waste-utilization plant; plant proper consists of two 5-drum Stirling-type waste-heat boilers of 6090 sq. ft. each, with feedwater heater and superheaters, which furnish steam at 150 lb. pressure, 100 deg. superheat; general arrangement and operation of equipment.

C

CASE HARDENING

Depth Measurement. Case Depth Measurement. Am. Soc. Steel Treating—Trans., vol. 15, no. 4, Apr. 1929, pp. 729–732. Recommended practice committee release: methods for measuring case depth include scale measurement of ordinary fracture, of blued fracture, of ordinary fracture which has been dipped in acid, and, of polished cross-sections; microscopic measurement of highly polished cross-sections; file or drill through from core at right angles to case until hardness of case resists further cutting or abrasion; magnetic analysis, etc.

CAST IRON

Nickel-Alloyed. Cast Iron with Nickel Additions (Nickellegiertes Gusseisen), H. Unger. Giesserei-Zeitung (Berlin), vol. 26, no. 7, Apr. 1, 1929, pp. 181–188, 12 figs. German experiences with nickel-alloyed cast iron; investigations of International Nickel Co.; graphite and grain-refining effect of nickel addition; it diminishes injurious effect of quenching and gives denser texture; effects increase in Brinell hardness and better machinability; increase in strength and durability; examples of its use.

CASTINGS

Internal Stresses. Internal Stresses (Sur les tensions internes), A. Le Thomas. Revue de Métallurgie (Paris), vol. 26, no. 2, Feb. 1929, pp. 87–90. Table is given showing results obtained on rough-cast test pieces reheated to different temperatures, with corresponding shearing-test values and Brinell hardness; responsibility incurred by founder in regard to stresses causing apparently spontaneous rupture. Paper read before Assn. Technique de Fonderie at Paris. See reference to English abstract from Foundry Trade Jl., Dec. 6, 1928, in Eng. Index 1928, p. 341.

CHIMNEYS

Vibration. Vibrations of Chimney Stacks (Schwingungen von Schornsteinen). Beton u. Eisen (Berlin), vol. 27, no. 21, Nov. 5, 1928, pp. 400–401. Formula developed by N. Mononobe, Tokio, for computing frequency of free vibration of hollow truncated cones, is recommended for use in investigating vibration of tall chimneys; frequencies of several chimneys and lighthouses as calculated from this formula and as measured are compared, and official specification is advocated of lower limit for frequency of chimney stacks and similar structures liable to be set in vibration by wind.

CHROMIUM-ALUMINUM STEEL

Properties. An Investigation of the Physical Properties of Certain Chromium-Aluminum Steels, F. B. Lounsberry and W. R. Breeler. Am. Soc. Steel Treating—Trans., vol. 15, no. 5, May 1929, pp. 733–762 and (discussion) 762–766, 13 figs. Physical properties investigated for steel containing as main alloying constituents, aluminum and chromium with silicon and carbon; aluminum effectively stabilized alpha-iron phase and when in combination with chromium, greatly increased resistance of metal to oxidation at elevated temperatures; addition of nickel produced unusual low-temperature phenomenon.

Chromargan. Chromargan, a Non-Oxidizing Steel [Chromargan (nichtoxydierender Stahl) und die Verchromung], W. Sack. Zeit. fuer die gesamte Giessereipraxis (Berlin), vol. 50, no. 8, Feb. 24, 1929, pp. 29–30. Alloy steel made by Krupp is said to possess remarkable properties: it is used for turbine blades, shafts, valves, cutlery and table ware, medical instruments, etc.; and is classified in two groups VM and VA; former has average chromium content of 13 to 15 per cent and small nickel content; latter has 18 to 25 per cent chromium content; VM is magnetic, and VA non-magnetic.

Creep Strength. The Creep Strength of a High Nickel High Chromium Steel, Between 600 Deg. C. and 800 Deg. C. H. J. Tapsell and J. Remfry. Dept. Sci. and Indus. Research—Report (Lond.), no. 15, 1929, 7 pp., 7 figs. Results of tensile and creep tests of forged bar 4 ft. long by 2 in. sq. finished at temperature of 950 deg. cent. consisting of 26.5 per cent nickel, 14.0 per cent chromium, and 3.59 per cent tungsten.

COAL

Drying. Drying of Coking Coal and Its Advantages (Die Kokskohletrocknung und ihre Vorteile). Brennstoff und Waermewirtschaft (Halle Saale), vol. 11, no. 2, Jan. 2, 1929, pp. 33–37, 1 fig. Notes on drying process, its economy and advantages; calculation of economy; savings effected by flue-gas preliminary drying; heat required per hour for coking coal.

Low-Temperature Carbonization. Low Temperature Carbonization, W. A. Bristow. Machy. Market (Lond.), no. 1478 and 1480, Mar. 1 and 15, 1929, pp. 187–188 and 243. Mar. 1: Progress of low-temperature movement; production of smokeless fuel; early difficulties; Parker retort and other systems; four types of retort; retorts in which coal is stirred; agitation of coal; rotating retorts; bleeding of coal; economic factors. Mar. 15: Application of low-temperature carbonization to cannel coal; influence of gasoline; small coal; large savings in distribution; lack of facilities for treating oil; price of smokeless fuel. Paper read before Instn. of Engrs. and Shipbldrs.

World's Largest Low Temperature Carbonization Plant. Am. Gas Jl., vol. 130, no. 4, Apr. 1929, pp. 26–28, 3 figs. New Brunswick, N. J., K.S.G. plant has annual capacity of quarter million tons of coal; process is designed from bituminous slack in single operation smokeless, free-burning fuel which can be screened into ordinary domestic sizes, together with usual yields of low-temperature tar, light oil, and high-calorific-value coal gas; description of retort; all units are built in duplicate, so that one spare is always available: steam plant consists of two 500-hp. boilers, operating at 200 lb. pressure and equipped with stokers to burn semi-coke breeze.

Synthetic Anthracite. Progress in Manufacture of Synthetic Anthracite—Synthracite (Un progres dans la fabrication de l'anthracite synthétique—le Synthracite), E. Gevers-Orban. Revue Universelle des Mines (Liége), vol. 72, no. 4, Feb. 15, 1929, pp. 93–98, 6 figs.; see also Génie Civil (Paris), vol. 94, no. 14, Apr. 6, 1929, p. 339, 1 fig. Description of low-temperature carbonization process for manufacture of anthracite briquets; details of plant at Bonne Fortune, Belgium; cost of plant and economics of process.

CONVEYORS

Package. Selective Package Conveyors, W. O. Hildreth. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 13–16, 1929, 5 pp., 7 figs. Two groups of selective conveyors are described, e.g., selective pin-type conveyor and selective tray conveyor for light articles; heavy-type selective tray conveyor; carton conveyor for warehouses and car loading; various uses of selective conveyors.

COOLING TOWERS

Improved Design. Cooling Towers. Ferro-Concrete (Lond.), vol. 20, no. 9, Mar. 1929, pp. 197–212, 8 figs. partly on supp. plates. Improved methods of design and construction; advantage of large units; rectangular towers; polygonal and circular towers; timber and steel towers; reinforced-concrete hyperbolic towers; examples of cooling towers.

Ventilation. Natural Ventilation of Cooling Towers (Natuerlich beluefteten Kuehltuerme), H. Petersen. Archiv. fuer Waermewirtschaft (Berlin), vol. 10, no. 4, Apr. 1929, pp. 147–149, 7 figs. Investigation based on draft action and laws of heat transfer and evaporation; influence of width of cooling zone on temperature of water; possibilities of improvement by reducing air resistance of built-in parts, by increasing height of tower, and increasing heat and water exchange surfaces.

COPPER ALLOYS

Casting Practice. Some Notes on Non-Ferrous Casting Alloys, W. Lambert. Can. Foundryman (Toronto), vol. 20, no. 3, Mar. 1929, pp. 29–30. Properties and casting practice for copper-aluminum bronzes and copper-tin group of alloys, true bronzes, including various types of red brass, gunmetal, and phosphor-bronze alloys, are described; Admiralty gunmetal; aluminum-bronze alloys susceptible to heat treatment; defective castings. From address read before Inst. of British Foundrymen.

CRANES

Forging and Monorail. Modern Lifting

Machinery. Mech. World (Lond.), vol. 85, nos. 2203 and 2205, Mar. 22 and Apr. 5, 1929, pp. 266–269 and 316–318, 16 figs. Mar. 22: Design and operation of forging cranes are discussed covering several types of Stothert and Pitt jib type forging cranes. Apr. 5: Design of monorail jib cranes is taken up including two Royce and one Stothert and Pitt design of monorail cranes.

CUPOLAS

Charging. A Novel Method of Cupola Charging, R. J. H. Ritchie. Foundry Trade Jl. (Lond.), vol. 40, no. 654, Feb. 28, 1929, pp. 159–160, 6 figs. Outline of method by which foundry owners may, by means of small capital expenditure, obtain mechanical charging and effective control of cupola; new truck is made of 3/8-in. plate with manganese-steel wheels loaded by one man; they are filled and wheeled on to weighing machine opposite bottom of cupola lift, which is of balanced or double-cage type, so that only lift is actual charge, and not cage or truck.

Influence of Inclined Charging Arrangement of Cupola on Melting Process (Der Einfluss der schraegen Beschickung des Kupolofens auf den Schmelzprozess), E. Knoppick. Giesserei-Zeitung (Berlin), vol. 26, no. 4, Feb. 15, 1929, pp. 109–110, 1 fig. It is shown through systematic investigations that mechanical charge as compared to hand charge has metallurgical disadvantages.

Design. Comparison of Principle of Poumay System With That of Regenerative Cupolas (Comparasion du principe du "Systeme Poumay" avec celui des cubilots à régénération qui l'ont précédé), P. Fils. Fonderie Moderne (Paris), vol. 23, Feb. 10, 1929, pp. 59–61. Principles of Poumay system are compared with earlier systems, showing advantages of former.

The Poumay Cupola, J. Cameron. Foundry Trade Jl. (Lond.), vol. 40, no. 657, Mar. 21, 1929, pp. 215–216, 4 figs. Poumay cupola is at moment most economical to be had; 54-in. diam. Poumay furnace melted too quickly to deal with when working with light castings; Poumay cupola requires very careful adjustment; it is essential that blast be properly adjusted as regards volume and pressure, and volumeter is necessary.

Practice. Production of High-Grade Cast Iron (Qualitaetsgusseisen), C. Gertreudts. Zeit. fuer die gesamte Giessereipraxis (Berlin), vol. 50, no. 7, Feb. 17, 1929, pp. 53–55. Deficiencies in design of cupolas are set forth and reference is made to melting process which was first tried out in early part of present century; recently experiments have been resumed with larger cupola, having diameter of 600 mm. and hearth capacity of 1000 kg.; it can be fired with coke, crude oil, or pulverized coal; results of melting tests are given in tables.

CUTTING TOOLS

Grinding. The Dry Grinding of Small Tools, N. N. Savin. Engineering (Lond.), vol. 127, no. 3301, Apr. 19, 1929, pp. 494–495. As result of experimental inquiry concerning limiting feeds and depths of cut in dry grinding of small tools, research engineer at Skoda Works, Pilsen, states that 70 per cent of taps and reamers which prove unsatisfactory have been damaged in process of grinding; in dry grinding high-speed steels with feed of 3 m. per minute, it is permissible to have width of cut of 3 mm., and depth of 0.05 mm. with possible maximum of 0.08 mm.; with alloy carbon steels corresponding figures are 0.03 and 0.05 mm., while for carbon steel standard is 0.02 mm.

Tungsten Carbide. How Tungsten Carbide Tools Influence Machine Design, E. G. Gilson, G. N. Sieger and W. E. Guild. Iron Trade Rev., vol. 84, no. 17, Apr. 25, 1929, pp. 1115–1117 and 1134, 6 figs. Increased machine capacity, greater power and higher speeds to be gained through use of this new alloy; troubles found with tool support, cross-compound slide, and tail-stock center; rigidity important factor; conditions governing feeds and cuts; tool shapes for turning, boring, milling, and planing materials with widia tools. Abstracts of two papers presented before Am. Soc. Mech. Engrs.

The Use and Abuse of Carboloy, E. G. Gilson. Am. Mach., vol. 70, no. 18, May 2, 1929, pp. 699–701, 3 figs. If users of tungsten-carbide alloys will realize importance of careful handling and grinding, much better results will be obtained with Carboloy tools; tungsten carbide ranks close to diamond in absolute hardness, but in ductility and thermal expansion is analogous to glass and must be handled accordingly; toughness in cutting edge of tool is imparted by technique of fabrication and through its cobalt content; soft grinding wheels are necessary.

CYLINDERS

Compressed-Gas, Testing. Testing Compressed Gas Cylinders, G. D. Bagley. Iron Age, vol. 123, no. 16, Apr. 18, 1929, pp. 1067–1069, 5 figs. Description of simple non-destructive tests which make it possible to determine wall thickness and condition of steel in every new cylinder which is placed in service at time cylinder is delivered from steel mill; present 5-year test affords data from which wall thickness of cylinders in service can be determined during life. Paper presented before Compressed Gas Mfrs. Assn.

D

DIES

Flanging. Making Irregular-shaped Flanged Cylinders. Machy. (Lond.), vol. 34, no. 860, Apr. 4, 1929, pp. 9–11, 5 figs. Description of flanging dies developed for use in quantity production of long oval-shaped cylinders from 22-gage sheet steel; flanging die of double type; die for trimming flanges; fixture for holding flanged cylinders while welding joint.

DIESEL ENGINES

Automotive. A Diesel-Engine Car. W. H. Goddard. Autocar (Lond.), vol. 62, no. 1743, Mar. 29, 1929, p. 652, 1 fig. Very great difficulties which had to be overcome in designing automotive Diesel briefly discussed; extreme simplicity of engine; advantages of oil fuel; experimental four-cylinder engine of 6.3 rated horsepower.

Light Diesel Engines for Automobile and Aircraft (Les moteurs Diesel Légers pour l'automobile et l'aéronautique), G. Delanghe. Génie Civil (Paris), vol. 94, no. 13, Mar. 30, 1929, pp. 306–309, 12 figs. Further discussion of mechanical-injection engines; construction of direct-injection engines including M.A.N. and Beardmore; design of Daimler Benz engine with anti-chamber injection.

Compressorless. Indicated Efficiency of Compressorless Diesel Engines (Der indizierte Wirkungsgrad der kompressorlosen Dieselmaschine), F. Schmidt. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 314, 1929, 22 pp., 26 figs. Critical discussion of usual methods of determining efficiency of Diesel engines; ideal method is developed for compressorless engines, taking into consideration change of specific heats with temperature, change in weight of load by injection of fuel, and difference in gas composition before and after combustion; tables used for specific heats are given. Bibliography.

Governors. Calculation of Energy of Diesel-Engine Governors (Die Berechnung der Energie von Dieselmotorenreglern), O. Holm. Archiv. fuer Waermewirtschaft (Berlin), vol. 10, no. 4, Apr. 1929, pp. 138–142, 9 figs. Relations between engine performance, fuel-pump design, and pump pressure on one hand and power of governor on the other are developed and reduced to simple formula with which it is possible to determine rapidly proper size of governor when data from engines of other size and power are available.

DROP FORGINGS

Heat Treatment. Heat Treatment of Drop Forgings, C. L. Foreman. Fuels and Furnaces, vol. 7, no. 4, Apr. 1929, pp. 497–500, 3 figs. Heat treatment of drop forgings in continuous furnace with automatic temperature control insures uniformity of product, as conditions of heating, time at heat, and weight of steel treated per hour, may be duplicated day after day; normalizing; annealing and hardening treatments.

DURALUMIN

Corrosion. Corrosion Resistance of Aluminum Alloys, H. S. Rawdon. Am. Mach., vol. 70, no. 15, Apr. 11, 1929, pp. 601–602. Cold working of properly heat-treated sheet duralumin by stretching or cold rolling does not affect very greatly susceptibility of material to intercrystalline attack; with improperly heat-treated duralumin this factor is of much more importance; exposure tests show that corrosion of pitting type may occur with duralumin; aluminum coatings are, by far, most dependable. Abstract of paper presented before Am. Inst. Min. and Met. Engrs.

E

ECONOMIZERS

Combined With Air Heaters. Combination Air Preheater and Economizer Developed by British Engineer. Power Plant Eng., vol. 33, no. 8, Apr. 15, 1929, p. 466, 2 figs. Brief description of Supermiser devised by A. E. Leek; essential feature is use of pairs of concentric tubes; flue gases pass through annular space between inner and outer tubes; feedwater to be heated passes in one direction through inner tubes and air to be heated in opposite direction over outside surface of outer or flue-gas tubes; gross overall thermal efficiency found to be 85.04 per cent.

Supermiser Installation at Ellesmere Port. Engineering (Lond.), vol. 127, no. 3296, Mar. 15, 1929, pp. 328–330, 7 figs. In this apparatus, which combines functions of economizer and air preheater, not only is relatively high velocity imparted to flue gases, but also to feedwater and air, and this results in marked improvement in efficiency of heat transmission through tubes; general arrangement of Supermiser installation at Ellesmere Port Works of Wolverhampton Corrugated Iron Co. is shown.

Design. Design and Proportions of Economizers and Air Preheaters, H. Webster. Am. Soc. Mech. Engrs.—Advance paper for mtg. May 13–16, 1929, 4 pp. Two distinct types of economizer are on market, vertical-tube and horizontal-tube; because of consequent higher rate of heat transfer, economizers should operate on counterflow principle; ideal air heater gives maximum heat-transfer rate with minimum draft loss, minimum leakage, minimum space requirements, and ease of access for cleaning and repair; different types are described; comparative analysis of number of typical combinations based upon their performance per foot width of furnace.

ELECTRIC FURNACES

Heat-Treating. Progress Made in the Use of Electric Furnaces for Heat Treating, A. N. Otis. Am. Soc. Steel Treating—Trans., vol. 15, no. 5, May 1929, pp. 767–794 and (discussion) 794–795, 13 figs. Present status of electric furnaces, extent of their use for heat treating, and some new types that have been recently developed; advantages for heat treating; some of individual furnaces and their operation briefly described; electric furnaces for forging; continuous furnaces for new process of copper brazing, and for annealing in atmospheres of protecting gas.

High-Frequency. Progress in Design of High-Frequency Furnace Installations (Fortschritte im Bau von Hochfrequenz-Ofenanlagen), M. Tama. Stahl und Eisen (Duesseldorf), vol. 59, no. 15, Apr. 11, 1929, pp. 499–502, 7 figs. Basic principles and developments in past few years; description of coreless induction furnace; electrical conditions in melting of magnetic and non-magnetic metals; general arrangement of high-frequency furnace; production of crucibles; electric current consumption.

Steel-Making. Dimensions, Operating Conditions and Performances of German Electric Steel Furnaces (Abmessungen, Betriebsverhaeltnisse und Leistungen deutscher Elektrostahloefen), St. Kriz. Stahl und Eisen (Duesseldorf), vol. 49, no. 13, Mar. 28, 1929, pp. 417–425 and (discussion) 425–427, 20 figs. Results of data compiled from questionnaire sent to electric steel manufacturers of Germany are critically discussed; among questions dealt with are primary voltage and performance of transformer, reactors, thickness of furnace lining, furnace material, charging, time required for melting, etc.

ELECTRIC WELDING

Arc. Better Fabricating Results by Arc Welding. Elec. World, vol. 93, no. 15, Apr. 13, 1929, p. 742. Experience of five years of Lewis-Shepard Co., Watertown, Mass., in fabricating portable elevators or stackers, lift platforms, racks, trucks, all-steel and combination steel-wood parts, related by chief engineer; elimination of noise and simplification of machinery; saving of material and experimental work made easier; lays stress on skill of operator and proper analysis of joint to be made before starting.

Machines for. Electric Welding Plant. Engineering (Lond.), vol. 127, no. 300, Apr. 12, 1929, p. 471, 2 figs. Details of two welding machines manufactured by A. I. Electric Welding Appliances Co.; first is 30-kw. automatic butt welding machine designed for dealing with wrought iron or steel up to 1 sq. in. in section, and for butt-welding tubes, etc.; second is spot welder rated at 10 kw., and when fitted with 9-in. arms will deal with work up to 1/4-in. thick.

EXECUTIVES

Profit Sharing for. Profit-Sharing an Incentive Plan for Executives, C. C. Balderston. Factory and Indus. Mgmt., vol. 77, no. 5, May 1929, pp. 968–970. Executive profit-sharing plans are found to add permanence to managerial force; factors which must be considered for management incentive system to be successful; details of three typical plans.

F

FLOW OF AIR

Orifices. Discharge Coefficients of Square-Edged Orifices for Measuring the Flow of Air. H. S. Bean, E. Buckingham, P. S. Murphy. U. S. Bur. of Standards—Jl. of Research, vol. 2, no. 3, Mar. 1929, pp. 561–658, 12 figs. Orifice plates; apparatus for measuring rate of discharge; flow nozzles; discharge coefficients of orifices for liquids and gases; methods of computation; discussion of errors; effects of viscosity; geometrical similarity and influence of pipe diameter; equations and numerical examples; coefficients of nozzles; similar orifices.

FLOW OF FLUIDS

Pipes. Application of the Theory of Similarity to Measurements of Flow (Anwendung der Aehnlichkeitstheorie auf Durchflussmessungen), A. Grunwand and F. Engel. V.D.I. Zeit. (Berlin), vol. 72, no. 21, May 26, 1928, pp. 699–702, 9 figs. Large number of new experiments on flow of water and steam through pipes of circular section and constant or varying diameter is collected; four parameters are taken into account: viscosity, diameter at point of measurement, nozzle coefficient, and total quantity flowing; results are reduced to curves which are substantially universal, and extend and conform previous work.

FLOW OF STEAM

Orifices. Measuring Steam Discharge by Means of Calibrated Orifices (La mésure des debits de vapeur à l'aide d'orifices calibrés), L. Kohler. Génie Civil (Paris), vol. 94, no. 15, Apr. 13, 1929, p. 363, 2 figs. Features of special orifices proposed in paper published in Oct. 1928, issue of Bul. des Associations Françaises de proprietaires d'Appareils à Vapeur.

FORGING

Machine. Principles of Machine Forging. H. Kilborn. Iron Age, vol. 123, no. 15, Apr. 11, 1929, pp. 1003–1005, 5 figs. Consideration of apparatus used and limiting conditions; how machinery was developed; trip hammers; how dies are used; many other uses for hammer; drop hammers; history of drop forging.

FUELS

Coal. See COAL.

Solid, Calorific Values. Different Methods of Calculating Calorific Value of Solid Fuels (Les diverses methodes de calcul du pouvoir calorifique des combustibles solides), P. Jarrier. Chaleur and Industrie (Paris), vol. 10, no. 107, Mar. 1929, pp. 107–112, 2 figs. Calculation of calorific power, based on elementary analysis and on direct measurement; various formulas based on both methods are given and discussed; comparative curves; Berthier methods of calculation, and improvements effected by Jueptner.

FURNACES

Electric. See ELECTRIC FURNACES.

FURNACES, MELTING

Design. High-Grade Cast Iron, Difficulties in Its Production, and Modern Production Methods (Qualitaetsguss, Schwierigkeiten bei seiner Ereugung, und neuere Herstellungsverfahren), Lincke. Giesserei-Zeitung (Berlin), vol. 26, no. 4, Feb. 15, 1929, pp. 104–108, 10 figs. Review of development in refining of cast iron in cupolas, electric and rotary furnaces; centrically and eccentrically operated rotary furnace; details of Buess rocker-type rotary furnace for oil, gas, or pulverized-fuel firing, in which, due to novel eccentric arrangement, change is constantly subjected to new and varying mechanical movement during operation.

Pulverized-Coal. Pulverized Coal-Fired Rotary Furnace for Malleable Cast Iron, H. Kalpers. Iron and Steel Industry (Lond.), vol. 2, no. 7, Apr. 1929, pp. 197–200, 9 figs. See also Foundry Trade Jl. (Lond.), vol. 40, no. 659, Apr. 4, 1929, pp. 257–258, 2 figs. Details of Brackelsberg pulverized-coal-fired rotary furnace; brief reference to Stotz process for manufacture of black-heart malleable cast iron, using cupola; former furnace has low loss through oxidation; neutral atmosphere is technical advantage; economy of melting compared. Translated from Zeit. fuer die gesamte Giessereipraxis (Berlin), Dec. 16, 1928.

G

GAS TURBINES

Lorenzen. The Lorenzen Exhaust Gas Turbine. Gas and Oil Power (Lond.), vol. 24, no. 283, Apr. 4, 1929, pp. 127–128, 4 figs. Description of series of tests carried out in Germany on Lorenzen exhaust gas blower fitted to 300-hp. Hispano-Suiza engine, and to 10-hp. Mercedes engine; method of cooling blades.

GEARS

Helicoidal Cutters for. Calculation for Milling of Spur and Worm Gears With Helicoidal Cutters (Kalkulation fuer das Fraesen von Stirn- und Schraubenraedern nach dem Abwaelzverfahren), K. Neumann. Werkstattstechnik (Berlin), vol. 23, no. 6, Mar. 15, 1929, pp. 179–181, 3 figs. Mathematical analysis with examples.

Modern Practice. Notes on Modern Gear Practice. World Power (Lond.), vol. 11, no. 64, Apr. 1929, pp. 385–386, 3 figs. Turbine-type gears, 1875 hp. 4500/6000 to 500 r.p.m., and 175 hp. from 1470 to 3638 r.p.m.; Sykes patent double-helical gear-cutting machine.

Tooth Wear. Causes and Effects of Wear on Gear Teeth, E. Buckingham. Am. Mach., vol. 70, no. 16, Apr. 18, 1929, pp. 638–640, 5 figs. Test data indicate that with clean oil and tooth loads below compressive fatigue limit of material, gear teeth will run indefinitely without appreciable wear; progress of wear on gear teeth is traced, and causes and effects of this wear phenomena are identified; pitting, abrasion, and cutting causes.

GRINDING

Machines, Germany. New Special Grinding Machine for Upkeep of Cutting Steels and Internal Grinding Work for Tool and Fixture Parts (Ein neue Sonderschleifmaschine fuer die Instandhaltung von Schneideisen und Innenschleifarbeiten fuer Werkzeug- und Vorrichtungsteile), O. Lich. Maschinenbau-Konstrukteur (Leipzig), vol. 62, no. 6, Mar. 15, 1929, pp. 125–129, 11 figs. New grinder of Carl Unger, Hedelfingen, is described.

Measurements. Investigation of Automatic Device for Measuring Grinding (Untersuchung einer automatischen Schleifmessvorrichtung), G. Berndt. Werkstattstechnik (Berlin), vol. 23, no. 7, Apr. 1, 1929, pp. 197–200, 6 figs. Investigations made on device manufactured by W. Grothkupp, Berlin, which is designed for automatically measuring round and grooved workpieces during operation.

H

HEAT EXCHANGERS

Heat Transmission in. Physical and Economic Relation of Heat Transfer and Pressure Loss (Der Physikalische und wirtschaftliche Zusammenhang von Waermeuebergang und Druckverlust), A. Schack. Archiv. fuer das Eisenheuttenwesen (Duesseldorf), vol. 2, no. 10, Apr. 1929, pp. 613–624, 1 fig. Inner relationship between frictional resistance and heat transfer; reconstruction of Fritsche's formula; heating surface and tube length required for heat exchanger; total pressure loss and total cost of heat transfer; most economical tube diameter; term, heat exchanger, is used to cover blast-furnace recuperators, regenerators, firetube boilers, etc.

HELICOGYRES

Discussion of. On Gyratory Wing-Traffic, C. G. Grey. Aeroplane (Lond.), vol. 36, no. 15, Apr. 10, 1929, pp. 561–562 and 564, 2 figs. Criticisms of helicopters in general and of V. Isacco's helicogyre; dangers of helicopting; Brennan helicopter; genesis of helicogyre; claims made by V. Isacco disputed; aerodynamic inefficiency of helicogyre; question of research of rotating wings to be explored by British Government; useless direct lifter.

HIGH-SPEED STEEL

Heat Treatment. Heat Treatment and Testing of High-Speed Tool Steels (Waermebehandlung und Pruefung von Schnellarbeitsstahl-Werkzeugen), F. Rapatz. Stahl und Eisen (Duesseldorf), vol. 49, no. 8, Feb. 21, 1929, pp. 250–255, 4 figs. Difficulties with spiral drills, milling cutters, etc., due to hardening temperature are set forth; barium chloride and borax salts baths; annealing at 500 to 600 deg. cent.; possibilities for high-speed tool steel.

I

IMPACT TESTING

Notched-Bar Test. Rating of Materials by the Notch Test (Beurteilung von Werkstoffen nach Kerbversuchen), W. Schwinning. V.D.I. Zeit. (Berlin), vol. 73, no. 10, Mar. 9, 1929, pp. 321–329, 35 figs. Recapitulation of recent studies of notched-bar testing; notch effects in elastic and plastic stresses; effect of method of fracturing (by impact, rapid bending, slow bending); effect of temperature, speed of deformation, etc., on fracture; special advantages of notch tests; standardization of notched-bar toughness testing.

INDUSTRIAL MANAGEMENT

Labor Turnover. A Basis for Reducing Labor Turnover, A. J. Zimmerman. Am. Mach., vol. 70, no. 16, Apr. 18, 1929, pp. 611–614, 1 fig. To hold plant operating costs, labor turnover must be kept low; costs of training new employees ranges from $50.00 to $200.00; before successful program can be developed, standard definitions and uniform system of calculation are needed; description of uniform system employed by Rochester industries for exchanging data on subject.

Measurement of Effectiveness. Rating Management Effectiveness on Kilo Man-Hour Basis Is Considered Possible, K. W. Stillman. Automotive Industries, vol. 60, no. 14, Apr. 6, 1929, pp. 546–549. System developed by L. P. Alford and J. E. Hannum for accurately measuring effectiveness of management is discussed with outline of steps which have been taken to apply system in industry; decision made by Census Bureau that 1929 manufacturing census shall include kilo-man-hour data obtained from selected group of industries; range of information which may be obtained by method.

Production Control. The Synchronization of Sales and Production, H. M. Hubbard. Am. Soc. Mech. Engrs.—Advance Paper, no. 14, for mtg., May 13 to 16, 1929, 6 pp., 6 figs. American executive realized that methods of yesterday are unsuited to problems of today, with result that new technique is being developed which visualizes business as coordinated and well-balanced whole; in majority of cases, coordination revolves about some kind of budget; operating schedules based upon forecasts prepared by sales department, which has made its plans upon careful market studies it is thus possible to prepare financial budget well in advance of operations and to estimate effectiveness of proposed program.

INDUSTRIAL PLANTS

Design. Hall Planetary Plant Has Unique Design and Operating System, K. W. Stillman. Automotive Industries, vol. 60, no. 7, Apr. 27, 1929, pp. 670–673, 4 figs. Description of unusual design of Philadelphia plant of Hall Planetary Co., which produces thread-milling machines for very accurate work; glass side walls and roof of building, as well as its elevated location and isolation from traffic noises, are novel features of industrial construction; no holes made in steel framework except those required in its erection so that, should plant be dismantled, salvage value of steel work would be nearly 100 per cent.

INTERNAL-COMBUSTION ENGINES

Atomization. Study of Atomization With Spray Carburetors (Untersuchung der von Spritzvergasern gelieferten Zerstäubung), J. Sauter. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 312, 1928, 30 pp., 72 figs. Investigations of fineness of atomization and liquid precipitations occurring in fuel line, in order to determine relation of atomization to different carburetor conditions, such as design of carburetor, fuel properties, etc.; method of determining average size of particles, based on optical effect developed by author.

High-Speed. Limits of Efficiency Increase Due to Control of High-Speed Internal-Combustion Engines (Begrenzung der Leistungssteigerungmaschine durch den Steuervorgang), M. Christian. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens (Berlin), no. 315, 1929, 19 pp., 20 figs. Study is made of how speed limit is governed by control action; investigation is confined to 4-stroke system and to stroke of 100 to 500 cu. m. per cylinder, generally employed for high-speed automotive engines; deals mainly with ordinary valve gear, in which valve opening is actuated by a cam and closing is operated by a spring; this type is compared with others.

Rating. Internal Combustion Engine Rating. W. A. Tookey. Gas and Oil Power (Lond.), vol. 24, no. 284, May 2, 1929, pp. 149–150. Explanation of Tookey factor which is useful basis of engine rating; factor can be of considerable use for commercial purposes without requiring knowledge of logarithms or slide rule; it becomes possible to realize more closely rating of individual engines in terms both of brake mean effective pressure and strength of mixture used, which ordinary figures for x lb. per b.hp. hour or y per cent of thermal efficiency do not indicate.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

J

JIGS AND FIXTURES

Design. Rules for Design, Their Proper and Improper Application in Fixture Design (Konstruktionsregeln, ihre falsche und richtige Anwendung im Vorrichtungsbau), M. Thanscheidt Maschinen-Konstrukteur (Leipzig), vol. 62, nos. 5 and 6, Mar. 1 and 15, 1929, pp. 102–106 and 131–132. Right and wrong design of parts of fixtures and tool machinery are discussed; duplex drawings shown both proper and improper arrangements.

K

KEYS AND KEYWAYS

Standardization. The Standardization of Keys and Keyways, W. Reavell. Engineer (Lond.), vol. 147, no. 3824, Apr. 26, 1929, pp. 456–459 and (discussion) 465–466, 28 figs. In conjunction with steady work on new tables of standards dealt with in this paper, reconstituted Committee has been investigating question of nomenclature, because of diverse names given in various parts of country to same form of key; final nomenclature, with illustrations of each type, is given. Paper read before Instn. Mech. Engrs.

L

LATHES

Cam-Turning. The Melling Cam-Turning Lathe. Engineering (Lond.), vol. 127, no. 3292, Feb. 15, 1929, pp. 215–216, 5 figs. For firms having output of five camshafts and upward per hour, installation of special cam-turning lathe will pay; leading feature of machine illustrated is that of turning whole of cams on camshaft at one operation either from rough forging or from concentrically turned shaft; machine shown is arranged for turning camshaft of six-cylinder motor-car engine with 12 cams.

LOCOMOTIVES

Diesel-Electric. Diesel-Electric Passenger Locomotives for New York Central Railroad, S. T. Dodd. Gen. Elec. Rev., vol. 32, no. 5, May 1929, pp. 273–277, 9 figs. New 900-hp. unit for service on Putnam division, length over inside of knuckles 59 ft., height 15 ft., width 10 ft., wheel base o.a. 49 ft.; continuous tractive effort 16,000 lb.; cab equipment: engine and auxiliaries; electric equipment and features of operation and control are described.

Freight, United States. Two Large American Locomotives, E. C. Poultney. Locomotive (Lond.), vol. 35, nos. 439 and 440, Mar. 15 and Apr. 15, 1929, pp. 98–100 and 116–118, 4 figs. Mar. 15: Details of two recently built freight engines of different design, one for operating heavy trains over normal profile; other of articulated type, works over line having exceptionally severe gradients while also hauling heavy trains; first is C. B. and Q. 2–10–4 type. Apr. 15: Details of second, which is Denver and Rio Grande Western locomotive.

High-Pressure. Winterthur High-Pressure Locomotive (La Locomotora Winterthur de alta presion), J. M. Buchli. Ingenieria y Construccion (Madrid), vol. 7, no. 75, Mar. 1929, pp. 125–131, 12 figs. Competition of electric and Diesel locomotives has forced builders of steam locomotives to be progressive; locomotive designed by Swiss factory at Winterthur is first to use high pressure steam exclusively; principal features of design are described; boilers; engine; auxiliary apparatus; technical data of comparison with low-pressure type; data on test run.

Oil-Electric, Switching. Westinghouse Builds 300 Hp. Oil Locomotive, D. G. Hershberger, R. O. Nash. Ry. Age, vol. 86, no. 14, Apr. 6, 1929, pp. 787–790, 6 figs. Locomotive for switching service is equipped with lightweight six-cylinder solid-injection oil engine rated at 300 hp.; special attention has been given to design of exterior of cab which is of welded-steel construction; control apparatus allows multiple operation; uses forced ventilation.

Operating Costs. Locomotive Performance and Operating Costs, A. F. Stuebing. Ry. Age, vol. 86, no. 17, Apr. 27, 1929, pp. 954–958, 11 figs. Study of interrelation of tonnage, rate of fuel consumption and speed, and their effect on expenses; rate of fuel consumption and tractive force at constant speed; dynamometer-pull-speed for various rates of fuel consumption; tender drawbar pull and coal per mile; tonnage hauled and ton-miles per hour at various rates of firing; unit coal consumption at various speeds with varying tonnage; cost of fuel and wages at various fuel rates and speeds.

Steam-Turbine. Development of the Ljungstrom Locomotive. Engineer (Lond.), vol. 147, no. 3823, Apr. 19, 1929, pp. 424–426, 5 figs. Third Ljungstrom locomotive, constructed by Beyer, Peacock and Co., made its first trip on Sept. 23, on L.M.S. Railway, and from that date to May 5, 1927, covered total distance of 5402 mi.; fourth Ljungstrom locomotive for Swedish State Railways is of same horsepower as Beyer-Peacock locomotive, namely 2000 b.hp. normal; it has also same 10–6–4 wheel arrangement, and is built to standard gage of track; comparison between turbine and piston locomotives; non-condensing turbine locomotive.

LUBRICATION

Theories. Kinetic Boundary Friction, J. H. Wells. Engineer (Lond.), vol. 147, no. 3824, Apr. 26, 1929, pp. 454–456, 3 figs. Results of experiments on behavior of boundary films of lubricants under steady shearing or rubbing motion, especially at comparatively high speeds; description of apparatus.

M

MACHINE TOOLS

Depreciation. The Depreciation Account, E. F. DuBrul. Am. Mach., vol. 70, no. 16, Apr. 18, 1929, pp. 619–622. Strong plea for abandonment of traditional cost accounting theories and for acceptance of realities; business men need something better to guide their policy as to replacement of machine tools to make sure that they have not omitted very essential element of depreciation in their cost sheets; progressive accountants believe it is important to show both costs and actual values for all assets in times of rising prices.

MACHINERY

Foundations, Vibration of. Vibrations in Foundations of Rotating Machines (Schwingungen von Fundamenten Rotierender Maschinen) P. Mueller. Bauingenieur (Berlin), vol. 10, no. 13, Mar. 29, 1929, pp. 228–234, 12 figs. Comparison of results of model test with theoretical determination; constrained vibrations of coupled systems; constrained vibrations in ground and in uniformly homogeneous elastic material.

MATERIALS HANDLING

Automobile Plants. Material Handling in the Pontiac Assembly Plant, N. H. Preble. Soc. Automotive Engrs.—Jl., vol. 24, no. 4, Apr. 1929, pp. 417–423 and (discussion) 423–424, 17 figs. Description of handling methods in new Pontiac assembly plant of Oakland Motor Car Co.; plant was designed without limitations as to space and for definite production program; production line is shown in detail; in chassis assembly line, hump, midway of length of building, raises chassis to mezzanine level to allow passage underneath; gravity conveyors carry storage batteries under floor and up beside assembly line.

Foundries. Electric Trucks in Foundries (Elektrokarren in Giessereien), Lucas. Giesserei (Berlin), vol. 16, no. 16, Apr. 19, 1929, pp. 365–374, 35 figs. Design and uses of electric truck in foundries are discussed in detail, and various different types are described and illustrated.

Low-Cost Production in Jobbing Shop, F. D. Campbell. Iron Age, vol. 123, no. 18, May 2, 1929, pp. 1212–1213. Description of how Eastern Steel Castings, Newark, N. J., revamped its plant, in seeking lower cost of production and greater output from same floor space; gravity conveyors for displacing man-power; great flexibility in operation; straight-line movements used; molder pushes his molds away from machine; production easily graduated to flow of orders; mold a minute made. Abstract of paper presented before Newark Foundrymen's Assn.

Mechanizing Foundry Operations of a Semi-Jobbing Character, D. G. Anderson. Iron Age, vol. 123, no. 15, Apr. 11, 1929, p. 1021, 2 figs. Description of unit in brass foundry of Western Electric Co. where several features have been introduced which it is believed would prove of advantage in average type of jobbing foundry; scraper-type conveyor automatically fills sand hoppers provided for each individual molder; conveying of unprotected molds.

Relationship of Building Plans to Foundry Handling Methods, E. F. Scott. Can. Machy. (Toronto), vol. 40, no. 7, Apr. 4, 1929, pp. 62, 64, 66, 68 and 78–79, 3 figs. Relation of foundry layout to materials-handling methods; yard equipment considered; runway details; mechanical charging equipment; care for future; structure design; equipment inside foundry; hot metal carrier uses monorail; handling molds; sand handling; shaking out; handling castings. Abstract of paper presented before Am. Soc. Steel Treating.

Wage - Payment Plans. Wage Incentive Plans as Applied to Receiving, Storing and Issuing of Raw Materials, H. H. Rothrock. Mill and Factory Illustrated, vol. 3, no. 3, Mar. 1929, pp. 33–35 and 112–118, 6 figs. Development of plans for new warehouse for castings of 16,000 different patterns representing combined weight of 100,000 sq. ft.; selection of trackage, platforms, and mechanical handling equipment; determination of minimum operating force.

METALS

Cold Working. Efficiency in Drawing and Cold Working (Der Wirkungsgrad beim Ziehen und Kaltwalzen), E. Siebel. Stahl und Eisen (Duesseldorf), vol. 49, no. 17, Apr. 25, 1929, pp. 561–566 and (discussion) 567, 12 figs. Notes on power and work requirements with loss-free deformation; experimental equipment; result of drawing tests; efficiency of deformation and materials stress with drawing; results of cold-working tests; influence of lubrication; losses in drive and their reduction, calculation of efficiency in cold rolling.

Press Working. Press Working and Forming of Metals, E. V. Crane. Metal Stampings, vol. 2, nos. 3 and 4, Mar. and Apr. 1929, pp. 173–182 and 261–264, 16 figs. Mar.: Special forming operations which may be performed either on presses or roll machine; operations discussed include bulging, beading, flanging, necking. Apr.: Discussion of necking in operations as performed on spindle lathes, swaging machines, and drawing dies; factors which govern extent of each drawing operation; calculation of forces involved in such reduction.

Temperature Effect. The Stability of Metals at Elevated Temperatures, C. L. Clark and A. E. White. Am. Soc. Steel Treating—Trans., vol. 15, no. 4, Apr. 1929, pp. 670–711 and (discussion) 711–714, 31 figs. Research was undertaken for purpose of answering three questions: (1) what relation, if any, exists between results obtained, from short-time tensile and long-time creep tests; (2) what are factors affecting stability of metals at elevated temperatures and (3) what mathematical relationship exists between variables encountered in long-time testing; results are given.

MOLDING MACHINES

Huge. Largest Molding Machine in Europe (Die groesste europaeisssche Formmasschine). Zeit. fuer gesamte Giessereipraxis (Berlin), vol. 50, no. 8, Feb. 24, 1929, p. 64, 1 fig. Details of machine made by Badische Maschinenfabrik Durlach for molding of converter bottoms for bessemer steel plant; weight of machine is 90,000 kg.

N

NICKEL ALLOYS

Welding. The Production of Ductile Welds in Nickel and Monel Metal, N. B. Pilling and T. E. Kihlgren. Am. Welding Soc.—Jl., vol. 8 no. 4, Apr. 1929, pp. 20–28, 1 fig. Nickel and monel metal excellently adapted for fabrication by fusion welding methods; production of welds which are strong, sound, and ductile requires adherence to suitable methods of welding rather than exercise of high degree of manual skill details of good methods discussed; methods of testing; metallic arc welds; carbon arc welds; oxyacetylene welds; cracking of welds; raw welds.

NITRIDATION

Details of Process. Surface Hardening of Special Steels with Ammonia Gas Under Pressure, R. H. Hobreck. Am. Soc. Steel Treating—Trans., vol. 15, no. 4, Apr. 1929, pp. 543–557

and (discussion) 557–568, 15 figs. Samples of special steels have been nitrided with ammonia gas under pressure and nature of case so produced has been examined; results show that increase in pressure of ammonia gas results in decrease in surface hardness but greatly increases depth of case produced in given time; curves are presented correlating hardness, time of treatment, and depth of case; explanation of phenomena observed.

Surface Hardening of Steel by Nitrogen, H. W. McQuaid. West. Soc. of Engrs.—Jl., vol. 34, no. 4, Apr. 1929, pp. 239–248, 2 figs. Failures and shortcomings as well as successes of nitriding processes are discussed; commercial process of hardening; depth and hardness of nitride case obtained at different temperatures; nitriding prevents corrosion; hardness measured at varying depths; process not yet fully understood.

O

OIL ENGINES

High-Speed. Notes on High-Speed Oil Engines, H. O. Farmer. Engineer (Lond.), vol. 147, no. 3823, Apr. 19, 1929, p. 444. Discussion of four-stroke high-compression oil engine only on its thermodynamical side, comparing its performance with that of gasoline engine. Brief abstract of paper read before Diesel Engine Users' Assn.

P

PAINT

Aluminum. Aluminum Paints as Heat-Resisting Coatings (Aluminiumfarben als hitzebestaendige Anstriche), O. Merz. Archiv. fuer Waermewirtschaft (Berlin), vol. 10, no. 4, Apr. 1929, pp. 156–157, 1 fig. Aluminum paints afford good protection of iron up to around 1100 deg. as they greatly reduce oxidation; influence of varying temperature on paint and adhesive strength of aluminum powders of different degrees of fineness and with different binding media.

PIPE, CAST IRON

Centrifugal Casting of. Centrifugal Casting (Centrifugation de la fonte), Posenti and Scorza. Revue de Métallurgie (Paris), vol. 26, no. 2, Feb. 1929, pp. 90–92, 5 figs. Review of developments in centrifugal iron castings; description of authors' system of casting pipe centrifugally, and their experience with process at Pesaro, Italy, where pipe of 200 to 350-mm. diam. and 4-m. length were made; with 12 flasks it is possible to produce 5000 to 7000 kg. of pipe in 8 hrs. at very low cost. Abstract of paper read before Assn. Technique de Fonderie.

PIPE LINES

Valves, Anti-Vacuum. Anti-Vacuum Valves for Pipe Lines. Engineering (Lond.), vol. 127, no. 3294, Mar. 1, 1929, pp. 266–267, 11 figs. Formation of vacuum in water conduits may lead to collapse of pipe with serious consequences; anti-vacuum valves are described which effectively protect against such contingency.

POWER PLANTS

Diesel-Electric, Costs. Diesel Engines for Office Buildings, E. J. Kates. Power, vol. 69, no. 18, Apr. 30, 1929, pp. 722–723. Diesel engine is particularly well suited for use in office, loft, and hotel buildings; it is complete power plant in itself, thus occupying little space; problems of reliability, vibration, noise, and maintenance cost are considered; labor costs are low, cost of electric current generated in proposed Diesel power plant is summarized in table. Abstract of paper presented before Am. Soc. Mech. Engrs.

PRESSURE VESSELS

Welding. Welding Vessels for High Pressures, P. R. Hawthorne. Am. Welding Soc.—Jl., vol. 8, no. 3, Mar. 1929, pp. 38–49, 16 figs. Characteristics of fluid-fusion process of welding its development and success, and its production application are described; means of producing deposited weld metal with tensile strength of from 68,000 to 74,000 per sq. in.; method of welding galvanizing kettle, annealing pots, 60-in. pressure pipes, and cylinders for 1800-ton hydraulic press.

PROJECTILES

Design. Projectile Design, W. L. Lukens. Army Ordnance, vol. 9, no. 52, Jan.-Feb. 1929, pp. 237–238. Discussion of tendencies in modern practice of projectile design; current tendency in field artillery projectile design is to eliminate false ogive or windshield, and obtain by careful designing, streamline projectile that may be readily forged, capable of having its streamline head easily formed, and with minimum amount of machining being required; tendency in design of armor piercing projectiles.

PUMPING STATIONS

Diesel, Lodi, N. J. A 75 Per Cent Cost Reduction With Diesel Pumping in the City of Lodi, N. J., K. Foster. Oil Engine Power, vol. 7, no. 5, May 1929, pp. 273–275, 2 figs. Details of operation of pumping station at Lodi, N. J., with savings obtained by use of Diesel engines; 110-hp. Ingersoll-Rand PO oil engine connected by flexible coupling to I-R air compressor and by short belt drive to double-suction, single-stage Cameron centrifugal pump.

Pittsburgh, Pa. Turbine-Driven Pumps Replace Engine-driven Units in Pittsburgh Pumping Station. Power, vol. 69, no. 17, Apr. 23, 1929, pp. 658–661, 6 figs. At Ross pumping station water is pumped from Allegheny River to filtration plant; new builders are of Stirling type, having 6000 sq. ft. of heating surface; steam is generated at 330 lb. pressure and superheated 200 deg.; boilers are fixed by six-retort underfeed stokers equipped with 300 per cent rating; they are driven by water turbines supplied with city water under pressure of 85 to 100 lb.; each pump is driven through reduction gear by impulse turbine; driving one pump at 410 r.p.m. at 340 r.p.m.

PUMPS

Boiler-Feed. New Problems in Boiler-Feed Pumps (Neue Probleme bei Kesselspeisepumpen), H. Kissinger. Archiv. fuer Waermewirtschaft (Berlin), vol. 10, no. 3, Mar. 1929, pp. 128–130, 7 figs. Physical principles governing design of hot-water pumps are discussed; new rule-of-thumb formula for determination of power requirement is given.

PUMPS, CENTRIFUGAL

Self - Starting. Self - Starting Centrifugal Pumps and Air Pumps of the Liquid-Seal Type, K. Ritter. Eng. Progress (Berlin), vol. 10, no. 4, Apr. 1929, pp. 90–91, 5 figs. Particulars of Shi pump constructed by Siemen and Hinsch; being self-starting, it is suitable for many operations for which standard centrifugal pump cannot be used where, for instance, it has to be started up and stopped frequently, as in fire-engine pumps, in domestic water-supply systems, and similar cases.

R

RAILWAY MOTOR CARS

Design and Maintenance. Rail Motor Design and Maintenance, E. Wanamaker. Ry. Mech. Engr., vol. 103, no. 4, Apr. 1929, pp. 175–180. Engines used so far in rail motors may be divided into two classes, one which carburates fuel, and one which supplies fuel to cylinders by means of solid-injection system; cooling system; definite maintenance organization required; refueling and housing motor cars.

REFRIGERATION

Absorption System. Renaissance of the Absorption Refrigeration Cycle, F. G. Keyes. Indus. and Eng. Chem., vol. 21, no. 5, May 1929, pp. 477–480, 5 figs. Principle of absorption refrigeration; improvements in small-water-absorption units; ammine-compound absorption machine; costs of operation and efficiency characteristics of absorption machines; adsorption freight-car refrigerating unit.

ROLLING MILLS

Broad-Flange Beams. The Manufacture of Broad Flange Parallel Beams, F. Trappiel. Rolling Mill Jl., vol. 3, no. 3, Mar. 1929, pp. 131–134. New process that fulfils all requirements and accomplishes thorough working of flange ends is described; finished beam has same structure and same physical properties in all cross-sectional parts; by straightening of double-bent flanges all rolling stresses are equalized. Abstract translated from Stahl u. Eisen, Nov. 1, 1928.

Roll-Pass Design. Roll Pass Design, W. Trinks. Rolling Mill Jl., vol. 3, no. 2 and 3 Feb. and Mar. 1929, pp. 67–70, 115–118, 12 figs. Forces between rolls and stock are discussed; factors involved in causing and in determining stress in rolls; bending moments and projected area of contact; calculation of forces acting on rolls; finding arc of contact; projection of arc of contact; bending and stress at various passes.

Strip. Rolling Bar Plates and Hot Strips, J. B. Ink. Iron Age, vol. 123, no. 16, Apr. 18, 1929, pp. 1070–1071, 3 figs. Description of continuous bar plant and hot strip mill recently placed in service by the American Rolling Mill Co., Middletown, Ohio; continuous mill of eleven stands uses flywheels on four only; close speed regulation needed in others; automatic control of coiler speeds; power requirements affected by many variables. Abstract of paper presented before Am. Inst. of Elec. Engrs., previously indexed from advance paper.

Semi-Continuous Rolling Mill for Steel Strip. Demag News (Duisburg), vol. 3, no. 2, Apr. 1929, pp. 29–33, 12 figs. Details of special strip-iron rolling train for Vereinigte Stahlwerke Aktiengesellschaft, Department August-Thyssen-Huette, Dinslaken, which acts semi-continuously, rolling strip in widths of 3.95 to 17.7 in. and thickness from 0.049 to 0.118 in., while delivering coils up to 0.3 ton in weight; strip train comprises continuous roughing train and open finishing train.

S

SAND

Foundry, Drying. Influence of Drying on Properties of Sand (Der Einfluss des Trocknens auf die Eigenschaften von Gebrauchssanden), H. Pinsl. Giesserei (Duesseldorf), vol. 16, no. 13, Mar. 29, 1929, pp. 285–291, 7 figs. Review of literature relating to influence of drying on sand mixtures; results of author's tests on prepared sands from different firms; numerical data on binding strength and gas permeability at different drying temperatures, varying water contents, etc.

SAWS

Metal-Working. A Bench Metal Saw, H. Haeneke. Eng. Progress (Berlin), vol. 10, no. 4, Apr. 1929, pp. 107–108, 2 figs. Small high-speed circular saw is intended to replace hack saws and other hand saws in cutting bars of small cross-section; with saw diam. of 4 in. this tool cuts at one setting round stock of diam. of 1.2 in., channel iron up to 1.2 in. by 1.3 in. and corresponding sizes of other shapes.

SMOKE ABATEMENT

London. The Pollution of the Air by Smoke, J. S. Owens. Mech. World (Lond.), vol. 85, nos. 2206 and 2207, Apr. 12 and 19, 1929, pp. 348 and 364–365. Apr. 12: Some aspects of smoke-pollution problem not so familiar to engineers; figures bearing on smoke problem in London are given. Apr. 19: Composition of domestic soot and of London air; in large cities about 50 per cent of ordinary daylight and sunlight lost is due to smoke haze; methods adopted for measuring degree of pollution of air; effect of wind velocity upon concentration of impurity; possible remedies. Abstract of paper read before Instn. Engrs. in charge.

SPRINGS

Manufacture. Springs for Service at High Temperatures, J. R. Fritze, R. J. Sutton and F. R. Porter. Heat Treating and Forging, vol. 15, no. 3, Mar. 1929, pp. 301–302 and 310, 6 figs. Selection of steel of suitable composition and proper treatments to facilitate its fabrication into springs is discussed; manufacturing operations described; elimination tests for steel; annealing and tempering; testing.

STEAM ACCUMULATORS

Constant - Pressure. Constant Pressure Steam Accumulator. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 10, Apr. 1929, pp. 554 and 556, 1 fig. In Kiesselbach system of constant-pressure thermal storage, water in storage tank is accumulated and maintained at both boiler pressure and temperature; water is circulated from boiler to accumulator and back again by means of circulating pump and pressure equilibrium pipe admits steam from boiler on to top of water in accumulator.

STEAM CONDENSERS

Regenerative. Regenerative Surface Condensers, T. Petty. Engineer (Lond.), vol. 147, nos. 3819–3821, Mar. 22, 29, and Apr. 5, 1929, pp. 313–316, 5 figs., 346–348 and 388–390, 21 figs. Characteristics of air-extraction apparatus and interrelation between vacuum, air leakage, air-extracting capacity and extent of secondary section; tube temperature in primary and secondary sections, thermal head, and extent of

secondary section in relation to condensate temperature. Principles and limitations of regenerative design; description of three specific designs.

STEAM-ELECTRIC POWER PLANTS

Holland, N. J. A departure in High Pressure Stations Operation. Elec. Light and Power, vol. 7, no. 4, Apr. 1929, pp. 32, 34, and 36, 4 figs. Holland station of New Jersey Power & Light Co., with ultimate capacity of 220,000 kw., is described; initial turbine installation, G.E. 55,000-kw. cross-compound unit, high-pressure element consisting of 11,800-kw. unit taking steam at throttle at 1250 lb. pressure and 750 deg. fahr. will operate at 3500 r.p.m.; 13,800 volt generator; low-pressure element will consist of 43,200-kw. unit operating at 1800 r.p.m.

London. The London Power Company. Engineer (Lond.), vol. 147, nos. 3820 and 3821, Mar. 29 and Apr. 5, 1929, pp. 342–344 and 386–388. 13 figs. partly on p. 354. Mar. 29: History of Deptford East Station and details of present equipment; there are nine turbines with capacity of over 100,000 kw.; pressure was raised to 325 lb.; power generated has increased from 32 to over 222 million units per annum. Apr. 5: Deptford West station is planned to contain six main generating units with capacity of 195,000 kw.; four sets are being installed, two rated at 27,500 kw. and two at 35,000 kw. each; station will start with 12 boilers.

STEAM ENGINES

Reciprocating, Heat Transmission in. The Transfer of Heat in Reciprocating Engines, A. Naegel. Engineering (Lond.), vol. 127, no. 3300, Apr. 12, 1929, pp. 466–469, 12 figs. Comparison of performance of engine with saturated steam at low speed with performance using steam superheated to 349.1 deg. cent. also at low speed; test in which saturated steam was used at lower speed of revolution; one of most valuable pieces of information obtained is that heat transferred to cylinder cover surface of uniflow steam engine is not of very great importance.

W. Nusselt's Theory of Condensation of Steam and Heat Transfer in Piston Engines (W. Nusselts Theorie der Kondensation von Wasserdampf und des Waermeueberganges in Kolbenmaschinen), Schmolke. Waerme (Berlin), vol. 52, no. 14, Apr. 6, 1929, pp. 261–266, 1 fig. Theory of surface condensation of steam is developed and its application to explanation of heat exchange in reciprocating engines is shown; heat exchange in gas engines is also discussed.

STEAM PIPES

Fittings. Fittings for High-Pressure Steam Installations (Armaturen fuer Hockdruckdampf), L. Kollbohm. Archiv fuer Waermewirtschaft (Berlin), vol. 10, no. 3, Mar. 1929, pp. 74–78, 23 figs. Use of high-pressure steam has created demand for special not yet standardized fittings; examples of new equipment are illustrated and discussed, including boiler-feed equipment, boiler valves, steam-pipe-line valves and fittings, etc.

STEAM POWER PLANTS

Coal Handling. Coal and Ash Handling. Nat. Elec. Light Assn.—Serial Report, Mar. 1929, 21 pp., 20 figs. Reports regarding introduction of molten-slag method of removing pulverized fuel ash from furnace; maintenance costs for various types of ash hoppers and gates for stoker-fired boilers; new coal-handling equipment; commercial disposal of ash; testing and operation of new coal distributor spout; use of drag scraper system for storing coal; motor-operated ash gate and new vestibule-type ash hopper are presented; problems to be studied by Committee are enumerated. Bibliography.

Design. Modern Tendencies in Super-Power Station Design, J. R. Finniecome. Power Engr. (Lond.), vol. 24, nos. 277 and 278, Apr. and May 1929, pp. 127–130 and 182–184, 5 figs. Apr.: Review of progress in Europe and America in power station development; advances in large steam-generating plants have been accelerated by use of pulverized fuel, which is most effective steam producer; central and unit systems of pulverized-fuel firing; economizer and air heater; hydraulic ash removal; large condensing turbines; size of units. May: Surface condenser and its auxiliaries considered with closed feedwater system.

Industrial, High-Pressure. A Résumé of High Steam Pressures in the Industrial Plant, P. W. Swain. Power, vol. 69, no. 15, Apr. 9, 1929, pp. 582–585, 1 fig. Possibilities of by-product power justify wide pressure range in industrial plants; most central stations of future will either stop short of 600 lb. or jump to 1200 lb. some industrial plants will find commercially best pressure at 600 or 800 lb.; power needed fixes pressure; methods of getting increased power from given weight of process steam are: to raise initial pressure, to lower process pressure, and to use more efficient units. Paper presented before Am. Soc. Mech. Engrs.

STEAM TURBINES

Back-Pressure. Steam-Turbine Regulations With Regard to an Economical Part-Load Operation, Especially in Case of Back-Pressure Turbines (Beitrag zur Frage der Dampfturbinen-eregelung im Sinne eines wirtschaftlichen Teillast-betriebes, isbesondere bei Gegendruckturbinen), K. Jaroschek. Waerme (Berlin), vol. 52, nos. 10, 11, and 12, Mar. 9, 16, and 23, 1929, pp. 203–206, 216–221, and 234–238, 17 figs. Comparison of rules for obtaining better part-load efficiency in back-pressure turbines; part-load efficiency with condensation turbines; most economical load in American turbines.

Testing. Load Dump Tests Made on Colfax Turbines, T. E. Purcell. Power, vol. 69, nos. 15 and 16, Apr. 9 and 16, 1929, pp. 590–592, 5 figs., and 627–630, 4 figs. Apr. 9: To determine effect of changes on governor characteristics of turbines at plant of Duquesne Light Co., load dumping tests were conducted during which maximum load that could be carried on machine with all valves wide open was released in one step; observations were made of maximum speed attained by unit and time taken for governor and main valve to react; equipment used during tests; turbine governors were improved so as to limit overspeeding to 9.1 per cent when full load is dropped. Apr. 16: Centrifugal oil-impeller governor on 40,000-kw. Colfax unit is described; mounted on end of turbine spindle is impeller of 16 in. outside diam. supplied with oil at 7 lb. pressure in inlet chamber; discharge pressure is 80 lb. at normal speed of 1700 r.p.m.; results of load-dumping tests; tests were made to determine speed jump with heaters and evaporator open to turbine; check valves were installed between two high-temperature heaters and turbine bleeder openings.

STEEL

Alloy. See ALLOY STEELS.

Chromium-Aluminum. See CHROMIUM-ALUMINUM STEEL.

Chromium-Nickel. See CHROMIUM-NICKEL STEEL.

High-Speed. See HIGH-SPEED STEEL.

STEEL CASTINGS

Temperature Effect. Some Mechanical Properties of Cast Steel at High Temperatures, F. Koerber and A. Pomp. Metallurgist (Supp. to Engineer, Lond.), Mar. 1929, p. 43. Results of tests carried out at temperatures up to 500 deg. cent. on 12 different cast steels; first tests comprised determination of usual tensile properties; notched-bar impact tests were also made at various temperatures. Abstract translated from Mitteilungen des Kaiser-Wilhelm Inst. fuer Eisenforschung.

STEEL, HEAT TREATMENT OF

Automobile Plants. Automatic Heat-Treating Methods in the Packard Plant. Am. Mach., vol. 70, no. 17, Apr. 25, 1929, pp. 664–665, 6 figs. Heat-treating unit consisting of three large furnaces and quench tank is illustrated in six halftones from Surface Combustion Co. and Packard Motor Car Co., each halftone being accompanied by brief description.

Quenching Oils. The Selection of Quenching Oils. Machy. (Lond.), vol. 34, no. 861, Apr. 11, 1929, pp. 41–44, 7 figs. Practical method of testing quenching oils is discussed; problem of selecting oil low in cost compared with sperm, but possessing as closely as possible its characteristics; behavior of oil when both large and small masses of material were quenched had to be considered; apparatus employed for quenching tests included thermocouple and test block; comparison of results of each test.

STOKERS

Design. Modern Stoker Practice for Water Tube Boilers, J. Bruce. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 10, Apr. 1929, pp. 509–511, 1 fig. Speaking generally, mechanical stoker equipment is divided into two classes: chain or traveling-grate types, and retort-type stokers; retort stokers are now being built for incorporation in boiler units of up to 300,000 lb. of steam per hour using air for combustion as high as 500 deg. fahr.

T

THERMOSTATS

Haughton-Hanson. The Haughton-Hanson Thermostat. P. J. Durrant. Engineering (Lond.), vol. 127, no. 3296, Mar. 15, 1929, p. 327, 3 figs. and (discussion) in no. 3297, Mar. 22, pp. 352–353. Apparatus is described which was used on annealing furnace to control temperature in investigation on constitution of cadmium-gold alloys; cold bulb of thermostat was kept at steady temperature near 25 deg. cent., and, for this purpose, small toluene thermostat was made consisting of two co-axial bulbs made of glass. Abstract of paper read before Inst. Metals.

TURBO-GENERATORS

Tropical Seawater. Turbo-Generator for Testing Out the Claude-Boucherot Process (Groupe turbo-dynamo pour l'essai du procédé Calude-Boucherot), G. Savourey. Industrie Electrique (Paris), vol. 38, no. 822, Mar. 25, 1929, pp. 136–139, 6 figs. Set is built by Alsacien Co. and installed for test purposes at banks of Meuse in d'Ougrée-Maihaye plant; must serve to utilize temperature differences between water at bottom and surface of tropical seas; capacity 50 kw., steam pressure 0.0323 kg. abs. per sq. cm.; temperature 25 deg. at inlet, 0.0125 kg. and 11.5 deg. respectively at outlet; one stage 800 mm. mean diam.; test results and characteristics are given.

W

WAGES

Bonus Systems. Pros and Cons of Group Bonus Aired, C. C. Balderston. Iron Age, vol. 123, no. 17, Apr. 25, 1929, pp. 1159–1160. Relative merits of group and individual incentives are discussed; preference for group bonus plan expressed; group plan stimulates co-operation; group incentive best adapted to progressive manufacture; setting task and measuring results; rules for individual incentive plan. Abstract of paper presented before Taylor Soc.

United States. Purchasing Power of Wages in United States (Ueber die Kaufkraft der Arbeitsloehne in den Vereinigten Staeten), Maschinenbau (Berlin), vol. 8, no. 6, Mar. 21, 1929, pp. W63–W65, 1 fig. Buying power considered on basis of totals of wages and production; marvel of American wages much decreased if viewed from standpoint of buying power; real income of American laborer is not much higher than European; cause has to be looked for in immigration restrictions rather than high protective tariff.

WELDED JOINTS

Design. Design of Joints for Welded Steel Structures, A. Vogel. Am. Welding Soc.—Jl., vol. 8, no. 4, Apr. 1929, pp. 68–82, 11 figs. Design of joints is reduced to analysis of stresses in various forms of joints, occasioned by application of welds in different positions, and by arrangement of members in positions best suited for welding; only those joints successfully used are given in detail; problems involved for various connections for individual members are analyzed and also assembly of individual members into trusses and structures.

WELDING

Electric. See ELECTRIC WELDING.

Nickel Alloys. See NICKEL ALLOYS.

Pressure - Vessel. See PRESSURE VESSELS.

WIND TUNNELS

Armstrong - Whitworth. The Armstrong-Whitworth Wind Tunnel, R. Reynolds. Flight (Lond.), vol. 21, no. 13, Mar. 28, 1929 (aircraft Engr. Supp.), pp. 20–23, 8 figs. Description of wind tunnel and balances recently installed in Whitely Works of W. G. Armstrong Whitworth Aircraft; tunnel is of type used at National Physical Laboratory, and is 46 ft. long with working section 5 ft. wide by 4 ft. high; three balances carried on steel frame fitted over top of tunnel; National Physical Laboratory duplex type of manometer used for measuring air speed.

WOODWORKING TOOLS

Boring Device. Fontaine System of Chill-Cast Disk Tools for Wood Boring (Travail du Bois Les Plateaux a Coquilles systeme Fontaine), E. H. Weiss. Pratique des Industries Mécaniques (Paris), vol. 11, no. 12, Mar. 1929, pp. 499–500, 6 figs. Description of series of boring tools for woodworking developed by M. Fontaine, head of Manufacture Parisienne de Société Outils; tools are developed from chill-cast disks but present important improvements, particularly for constant-profile relieving; tools are practical in making variety of moldings. From Recherches et Inventions, Aug. 1928.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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What It's All About

THOMAS Tredgold, who died just one hundred years ago, defined engineering as "The art of directing the great sources of power in nature for the use and convenience of mankind." Twenty-one years ago, Henry G. Stott, then president of the A.I.E.E., revised this definition to read, "The art of organizing and directing men and controlling the forces and materials of nature for the benefit of the human race."

Thus has the field of engineering broadened to include the man as well as the machine. Every month MECHANICAL ENGINEERING bears witness to the increasing extent of engineering activity. This supplement describes the contents of the July issue. Read it and pass it on to let some one else know "What it's all about."

Wage Incentives

ONE of the contributions which engineers have made to our social structure is a study of the fundamentals of wage payment. The obviously simple method of paying a man for his time or for the amount of work he produces leads to abuses by workman and employer which cause industrial unrest and economic and social waste. Engineers have devised schemes which correct these abuses and work to the mutual advantage of employer and employee.

Financial incentives in the form of bonuses and profit sharing are an important part of modern wage-payment systems. Charles W. Lytle, in the leading article in MECHANICAL ENGINEERING for July, discusses "Wage Incentives for Direct Labor." Mr. Lytle has investigated many schemes, and in his article he analyzes ten which meet all the requirements for direct-production work.

Loading Mine Cars

IT WAS the flooded mines of Cornwall which made necessary the development of the steam engine to drive pumps. Long before steam engines were used for other power purposes they were at work in the mines. The mining industry was also responsible for the invention by Stephenson of the steam locomotive, and the hauling of coal was the first service to which the locomotive was put. Hoisting equipment in mines is of ancient origin, and more lately machinery has been used for ventilation, for drilling, undercutting, and for hauling coal underground.

The most recent application of machinery in coal mines has been that made to the loading of cars underground, and here the conditions differ so vastly from those above ground that the greatest ingenuity is necessary in designing and operating the equipment. In the July issue of MECHANICAL ENGINEERING, O. G. Scharrer describes "Recent Developments in the Mechanical Loading of Coal in Mine Cars." An important and interesting part of Mr. Sharrer's paper is his discussion of the effect which mechanization has had upon the labor situation at the mine to which he is attached. There are also tabulated data on investment costs of mechanical coal-loading installations at the Union Pacific Coal Company's mine from 1923 to date.

Radio and Aircraft

HERE are two infant industries helping each other. The radio has come to the aid of art of flying by making it possible to fly blindly in fog to a given destination, the course being directed not by the pilot's ability to recognize the country over which he is flying or to set a course and follow it by estimating and correcting for probable deviations. Aside from this navigational aid, the radio offers also the possibilities of communication, telegraphic and telephonic, and landing in fog.

At the Fourth National meeting of the A.S.M.E. Aeronautic Division, held in St. Louis in the latter part of May, J. A. Dellinger and H. Diamond of the Bureau of Standards presented a paper on "Radio Developments Applied to Aircraft." It is to be found in the July issue of MECHANICAL ENGINEERING.

Marble Quarrying and Milling

KNOXVILLE, TENN., famous for its marble quarries, provided a meeting place for the A.S.M.E. last March and an opportunity to study an important local industry. The quarrying and cutting of stone is an ancient art which has become mechanized in the age of machinery. The engineering features of this industry are set forth in the July issue of MECHANICAL ENGINEERING by J. P. McCluskey, who describes the quarrying and milling operations performed in the production of marble. Moldings, columns, and fluted and curved work are formed in machines resembling the familiar lathe and planer. Carborundum wheels with proper contours are used for much of the work and have practically replaced steel tools.

Research in Gear Teeth

PROGRESS Report No. 14 of the A.S.M.E. Special Research Committee on Strength of Gear Teeth is further evidence of the activity of research in this field. This report, published in the July issue of MECHANICAL ENGINEERING, covers a series of tests made under conditions which caused the contact surfaces of the gear teeth to fail so that tentative equations developed in earlier reports could be tested for their general accuracy. The report states that the results of the tests have given increased confidence in the mathematical analysis.